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Assessment of Haddock on Eastern Georges Bank

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Évaluation d'aiglefin sur l'est du banc Georges

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ABSTRACT

Haddock catches from eastern Georges Bank fluctuated around 5,000 t from 1985 to 1990. Under restrictive management measures, combined Canada/USA catches declined from over 6,400 t in 1991 to a low of about 2,100 t in 1995, fluctuated between about 3,000 t and 4,000 t until 1999 and have since increased to about 7,500 t.

Adult population biomass (ages 3+) has steadily increased from near an historical low of about 10,000 t in 1993 to about 78,000 t at the beginning of 2003 but remains below the average biomass during 1930-55. The recent increase was supported by improved recruitment in the 1990's. The 2000 year-class is estimated to be larger than the strong 1975 and 1978 year-classes. The fishing mortality rate for fully recruited ages 4+ has consistently been below the threshold reference target (F_{ref}) of 0.26 since 1995. Reduced fishing mortality and avoidance of small fish in the fisheries in recent years has resulted in increased survival of incoming year-classes and greater abundance at older ages.

With an assumed total catch of 8,000 t in 2003, a combined Canada/USA catch of 8,000 t in 2004 would result in a low probability that the fishing mortality rate in 2004 will exceed F_{ref} . At this yield, there is a negligible probability of achieving a 10% biomass increase from 2004 to 2005, due to the 2 weak incoming year-classes, 2001 and 2002, but there is a low probability that the biomass will fall below the median 2005 rebuilding biomass of 65,000 t. The population age structure shows good representation at all ages.

RÉSUMÉ

Les prises d'aiglefin dans le secteur est du banc Georges ont fluctué autour de 5 000 t de 1985 à 1990. Sous le coup de mesures de gestion restrictives, les prises canado-américaines combinées ont chuté, passant de plus de 6 400 t en 1991 à un creux d'environ 2 100 t en 1995, puis ont fluctué entre quelque 3 000 à 4 000 t jusqu'en 1999 pour ensuite augmenter, se situant depuis à quelque 7 500 t.

La biomasse de la population d'adultes (3+ ans) a progressivement augmenté, pour passer d'un creux presque historique d'environ 10 000 t en 1993 à environ 78 000 t au début de 2003, bien qu'elle demeure inférieure à la biomasse moyenne de la période 1930-1955. Cette récente augmentation est imputable à l'amélioration du recrutement dans les années 1990. La classe d'âge 2000 est estimée comme étant plus abondante que les fortes classes 1975 et 1978. Depuis 1995, le taux de mortalité par pêche des classes de 4+ ans pleinement recrutées a régulièrement été inférieur au taux de référence cible (F_{ref}) de 0,26. Le taux réduit de mortalité par pêche et la protection des petits individus de la pêche dans les dernières années ont résulté en un taux de survie accru des classes d'âge en voie de recrutement et une plus forte abondance de poissons plus âgés.

À un niveau supposé de prises totales de 8 000 t en 2003, il est peu probable que des prises canado-américaines combinées de 8 000 t en 2004 résulteraient en un taux de mortalité par pêche supérieur à F_{ref} cette année-là. À ce niveau de rendement, la probabilité que la biomasse augmente de 10 % entre 2004 et 2005 est négligeable parce que les deux classes d'âge en voie d'être recrutées, soit les classes 2001 et 2002, sont peu abondantes, mais il existe une faible probabilité que la biomasse diminuera, pour se situer en 2005 sous la biomasse médiane requise pour le rétablissement du stock, soit 65 000 t. La structure des âges dans la population révèle que ceux-ci sont tous bien représentés.

Introduction

Since 1990, Canada has used eastern Georges Bank, statistical unit areas j and m in NAFO sub-division 5Ze (Figure 1), as the basis for a management unit (Gavaris 1989), referred to as 5Zjm for brevity. Canada and the USA jointly develop management measures for Georges Bank transboundary stocks including haddock. The 5Zjm management unit was adopted as the basis for a sharing allocation proposal (DFO 2002). This assessment applies the approach used by Gavaris and Van Eeckhaute (2002) using Canadian and USA fisheries information updated to 2003. Results from the Fisheries and Oceans Canada (DFO) survey, updated to 2003, and the USA National Marine Fisheries Service (NMFS) surveys in the spring, updated to 2002 and 2003, and fall, updated to 2002, were incorporated.

The Fishery

Commercial Catches

Haddock on Georges Bank have supported a commercial fishery since the early 1920s (Clark et al 1982). For details on the historical aspects of the Georges Bank haddock fishery see Gavaris and Van Eeckhaute (1998).

Under restrictive management measures, combined Canada/USA catches declined from over 6,400 t in 1991 to a low of about 2,100 t in 1995, fluctuated between about 3,000 t and 4,000 t until 1999 and has since increased to over 7,000 t (Table 1, Figure 2). Greater catches in the late 1970s and early 1980s, ranging up to about 23,000 t, were associated with good recruitment. Substantial quantities of small fish were discarded in those years (Overholtz et al 1983). Catches subsequently declined and fluctuated around 5,000 t during the mid to late 1980s.

Total catches during the 1930s to 1950s ranged between 15,000 t and 40,000 t (Figure 3), averaging about 25,000 t (Schuck 1951, R. Brown pers. com.). Records of catches by unit area for the early 1960s period have not been located, however, based on records for Subdivision 5Ze, catches probably attained record high levels of about 60,000 t during the early 1960s. Since the early 1970s, catches have been substantially lower, generally fluctuating between 5,000 t and 10,000 t.

Except for the year 2000, Canadian catches since 1995 were below the quota due to closure of some fleet sectors when the cod quotas were reached. The 2000 catch of 5,402 t was slightly above the Canadian quota of 5,400 t. The 2002 Canadian groundfishery catch was 6499 t. Since 1994, all Canadian groundfish fisheries on Georges Bank remained closed from January to early June.

Weight of all Canadian landings were monitored at dockside. At-sea observers monitored 10% of the haddock caught. In 2002, samples were collected by DFO, observers and by two industry groups, Scotia Fundy Mobile Gear Fishermen's Association and High Liner

Foods. Discarding and misreporting by the groundfishery have been considered negligible since 1992.

In recent years, the Canadian fishery has been primarily conducted by vessels using otter trawls and longlines with some handlines and gillnets. During 2002, all vessels over 65 ft operated on enterprise allocations, otter trawlers under 65 ft and fixed gear vessels 45-65 ft operated on individual quotas while fixed gear vessels under 45 ft operated on community quotas administered by local boards (Table 2). Most haddock were caught by otter trawlers and longliners in tonnage classes 2 and 3 vessels less than 65 ft in overall length (Table 3). The highest catches occurred in July (Table 4, Figure 4). The Canadian fishery management plan initial allocations by fleet sector (final allocations may differ due to transfer of quota between fleet sectors) and reported landings are shown below:

Fishery Sector	1998		1999		2000		2001		2002	
	Quota	Catch	Quota	Catch	Quota	Catch	Quota	Catch	Quota	Catch
Fixed gear <65'	915	856	928	902	1271	1193	1731	1660	1644	1527
Mobile gear <65'	1984	1997	1972	1964	2743	2796	3465	3432	3367	3333
Fixed gear 65'-100'	39	39	39	8	54	51	70	2	0	0
Mobile gear 65'-100'	94	93	188	186	54	224	547	540	235	235
Vessels >100'	868	386	773	590	1278	1137	1176	1140	1494	1400
Totals	3900	3371	3900	3650	5400	5402	6989	6774	6740	6496

Source: Quota reports (will not match statistics exactly)

Since 1996 the Georges Bank scallop fishery has been prohibited from landing haddock and no estimates of haddock bycatch by this fishery have been available. In 2001-2002, a monitoring program was conducted by the Canadian offshore scallop industry to examine bycatch of several species, including haddock. Twelve observer deployments on offshore scallop vessels were conducted between May 2001 and April 2002 with most trips occurring in 5Zj. During each observed trip, approximately 80% of the scallop tows were monitored for bycatch. Since there is a seasonal component to the groundfish movements on the bank, haddock bycatch ratios (weighted averages) were calculated as a percentage of total scallop catch and total effort grouped by trimester. These ratios were then multiplied by the 2001 and 2002 offshore scallop catch and effort (for each trimester) and summed to provide estimates of total haddock bycatch for these two years. Since the offshore scallop fishery is under quota management, it was assumed that the effort-based calculations would be more reflective of haddock bycatch, although both methods yielded similar results. Discards from this fishery are estimated to be 19 t in 2002 and 22 t in 2001.

USA catches for 2002 were derived from logbooks coupled with dealer reports using the same procedures as for 1994-2001. Effort in the USA fishery was regulated using closed areas, days-at-sea limits, and trip limits (Table 2). Trip limits were introduced in 1994 and daily catch limits in 1996 to reduce targeting of haddock. Low trip limits resulted in an increase in discard rates. Trip limits have been adjusted periodically to reduce discarding of haddock. Since 1999, the maximum trip has been 50,000 pounds per trip with a daily limit of 5,000 pounds. The daily trip limit was suspended in July 2002 to reduce discards. The combination of area closures, effort restrictions, and trip limits has precluded most operators from making long trips to 5Zjm, with the result that USA catches from 5Zjm have been relatively low since 1993. While Area II remained closed in 2002, landings from 5Zjm, which come almost exclusively from tonnage classes 3 and 4 otter trawlers (Table 5), increased to 944.8 t and discards again were low because the day and trip possession

limits remained high. Catches by month have not been available since 1993 (Table 6) but quarterly landings totals in 2002 were: 165 t (17%), 605 t (64%), 99t (10%) and 76 t (8%) (Table 7). USA landings were evenly distributed between large 491 t (52%) and scrod 438 t (46%) market categories. A total of 15.8 t of unclassified haddock were apportioned to large and scrod market categories.

Size and Age Composition

The size and age composition of the 2002 Canadian fishery was characterised using port, at sea and industry samples from all principle gears and all seasons. Comparison of length frequencies from these sources did not reveal any persistent differences (Figure 5), therefore, all data was combined (Table 8, Figure 4). The size composition of catch in the Canadian fisheries peaked at 51 cm (20 in) for otter trawlers and at 58 cm (23 in) for longliners (Figure 6). Gill-netters caught few haddock but they were larger. Although haddock discard length sampling from the Canadian scallop fishery is available from the industry study that took place in 2001 and 2002, no data are available to weight the length measurements by numbers caught per set. Therefore, these discards are not included in the catch at age. The amount of discards estimated by the industry study is minimal and, in previous years, landings from this fishery were small so omitting landings from this source should not unduly impact the catch at age.

Length samples from USA 5Zjm landings were inadequate to characterise the fishery and were augmented by length samples from areas 521 (5Zg), 522 (5Zh) and 525 (5Zn). Age sampling was also inadequate and was augmented with 2002 DFO survey data for quarter 1 and with the 2002 Canadian commercial age length keys for quarters 2, 3 and 4 (Table 7). The size composition of the catch in the 2002 USA fisheries was 53% large, peaking at 60cm and 47% scrod, peaking at 53 cm. The scrod market category size composition samples did not contain any fish below 43 cm.

Ages of survey and commercial-caught haddock were separately assigned by DFO and NMFS age readers. For the DFO reader, intra-reader agreement tests were conducted in 2002 and indicated that DFO age interpretations were internally consistent. Results of between-reader comparisons were less consistent (68% agreement), especially for age-2 and age-3 fish. This led to concerns about a possible bias in age interpretations. (Appendix A). These concerns will be addressed at a joint NMFS-DFO ageing workshop scheduled for 2004. The NMFS ageing group is in the process of training a new haddock ager and this workshop will also help in establishing consistent age determinations with the new ager.

The 2002 catch at age by quarter for Canada and the USA (Table 9) and a revised 2001 catch at age was used to augment the 1969-2000 results (Gavaris and Van Eeckhaute, 2002). The 2001 catch at age was adjusted to reflect revised landings. Combined Canada/USA annual catch at age and average fishery weights at age are summarized in Tables 10 and 11 and Figure 7. The 1998 year-class (age 4) dominated the 2002 catch as it did in 2001. The 1996 year-class (age 6) contributed the next highest component. In comparison to the age composition of the catch during periods when year-classes were quickly fished down, the older age groups (ages 9+) continued to contribute significantly to the 2001 catch (Figure 8). The percentage of age 2 fish in 2002 was well below historical averages. The low percentage of younger ages in the recent catches has been due in part to

the type of gear used and to avoidance of areas with small fish. The age composition during the 1969 to 1974 period was dominated by the outstanding 1962 and 1963 year-classes which continued to contribute substantially as older fish and is not considered typical.

Abundance Indices

Commercial Catch Rates

Catch rates from the Canadian commercial fishery for selected trips (i.e., only those vessels which reported more than 1 t from 5Zjm during 1994 where cod, haddock and pollock comprised over 90% of the total catch) for tonnage classes 2 and 3 otter trawlers and longliners have generally increased since 1993 to 2000 but have leveled out since then (Figure 9). Changes to regulations, gear modifications and varying fishing practices in recent years make comparison of catch rates from year to year difficult to interpret. Therefore, these were not used as indices of abundance.

Research Surveys

Surveys of Georges Bank have been conducted by DFO each year (February) since 1986 and by NMFS each fall (October) since 1963 and each spring (April) since 1968. All surveys used a stratified random design (Figures 10 and 11). For the NMFS surveys, two vessels have been employed and there was a change in the trawl door in 1985. Vessel and door type conversion factors (Table 12), derived experimentally from comparative fishing, have been applied to the survey results to make the series consistent. Additionally, two trawl nets were used on the NMFS spring survey, a modified Yankee 41 during 1973-81 and a Yankee 36 in other years, but no conversion factors are available for haddock (Forrester et al 1997).

The spatial distribution of catches for the most recent surveys of each series was similar to the distribution over the previous 5 year period (Figures 12, 13, 14 and 15). In winter/spring, adults (ages 3+) are more abundant on the Northern Edge but age 1 fish are distributed broadly over the bank. The 2000 year-class was well represented in all surveys, at age 2 in the 2002 NMFS spring and fall surveys and as age 3 in the 2003 DFO and NMFS spring surveys. All surveys had very low catches of the 2001 and 2002 year-classes. The distribution of ages 2 and 3+ in the NMFS 2002 survey was more evenly spread throughout the survey area and especially on the southern flank than is normally seen at this time of year. In fall, adult haddock are more concentrated in the deeper waters along the slopes of the Northeast Peak and the Northern Edge, however, age 1 fish remain somewhat more widespread.

Age specific abundance patterns from the three surveys track year-class strengths fairly well (Tables 13, 14 and 15; Figure 16). Some year effects are evident, for example, the low spring catches observed for both the 1997 DFO and NMFS surveys. The indices for ages 3-8 survey biomass peaked at record highs during the early 1960s (Figure 17). After declining to a record low in the early 1970s, they peaked again in the late 1970s, though at a lower level, and again during the mid to late 1980s at about half the level of the 1970s

peak. Biomass generally increased during the 1990s, and the most recent increase is due largely to the 2000 year-class. The NMFS 2002 fall survey abundance is at its highest level since 1976.

Survey recruitment indices for ages 0, 1 and 2 indicate that the abundance of the 2000 year-class is comparable to the good 1975 and 1978 year-classes, with the 1998 year-class being the second strongest since the 1978 (Figure 18). The 1996 and the 1999 year-classes were comparable to the moderate 1983, 1985, 1987 and 1992 year-classes. These year-classes were considerably smaller than the strong 1975 and 1978 year-classes and the exceptional 1963 year-classes. Early indications from survey results suggest that the 2001 and 2002 year-classes are weak.

Although fishery weights at age (Table 11, Figure 19) for ages 2 and 3 are higher since 1993/1994, reflecting the change in gear selectivity which occurred, there have been no persistent trends in population weight at age derived from the DFO surveys. The survey weights at age (Table 16, Figure 20) for 2002, while generally within the range of observation, were notably lower than for 2001 but several have increased in the most recent 2003 survey. Average weight at age of haddock from the 1989, 1990 and 1991 year-classes were higher than adjacent year-classes in both the surveys and the commercial fisheries, giving the false impression of a declining trend in recent years. The method of calculation of the weights at age from the DFO survey, which were used for beginning of year population weights, was given in Gavaris and Van Eeckhaute (1998) and were derived from weights observed during the survey, weighted by population numbers at length and age. Fishery weights at age are derived from a length-weight relationship (Waiwood and Neilson 1985). In some cases, the mean weight at age in the catch is larger than the population mean weight at age at the beginning of the following year for the same cohort. This feature was mostly attributable to bottom trawl gear changes which resulted in a change in partial recruitment since 1994 (Gavaris and Van Eeckhaute, 2000). However, some discrepancies in weights at age were more persistent and may be due to problems associated with the length weight equations and gutted to round weight conversion factors. DFO survey weights at length were used as an indicator of condition and were calculated from observed lengths and weights. The average weights for 3 adjacent 2 cm length groupings exhibit no notable trends (Figure 21).

Estimation of Stock Parameters

Calibration of Virtual Population Analysis (VPA)

The adaptive framework, ADAPT, (Gavaris 1988) was used to calibrate the virtual population analysis with the research survey abundance information. An investigation of model formulations and model assumptions was conducted by Gavaris and Van Eeckhaute (1998) where details of model equations and the objective function are provided. The model formulation adopted assumed that the random error in the catch at age was negligible. The errors in the abundance indices were assumed independent and identically distributed after taking natural logarithms of the values. The annual natural mortality rate, M , was assumed constant and equal to 0.2. Similar model assumptions and methods were

applied to the updated information here. Minor differences in the handling of zero terminal catches for a year-class were implemented as a refinement to the software to afford more flexibility. The population abundance for the 9+ age group was calculated but not calibrated to the indices. In the first quarter of the first year, the 9+ abundance calculation was based on the assumption that the fishing mortality for the 9+ age group was equal to the population weighted fishing mortality for ages 4 - 8. In the first quarter of subsequent years, the 9+ abundance was calculated as the sum of the age 8 and age group 9+ abundances at the end of the last quarter of the previous year.

The VPA used quarterly catch at age, $C_{a,t}$, for ages $a = 0, 1, 2 \dots 8, 9+$, and time $t = 1969.0, 1969.25, 1969.5, 1969.75, 1970.0 \dots 2002.75, 2003.00$ where t represents the beginning of the time interval during which the catch was taken. The VPA was calibrated to bottom trawl survey abundance indices, $I_{s,a,t}$, for

$s = \text{DFO spring, ages } a = 1, 2, 3 \dots 8, \text{ time } t = 1986.16, 1987.16 \dots 2002.16, 2003.16$

$s = \text{NMFS spring (Yankee 36), ages } a = 1, 2, 3 \dots 8, \text{ time } t = 1969.29, 1970.29, 1971.29, 1972.29, 1982.29, 1983.29 \dots 2003.25$

$s = \text{NMFS spring (Yankee 41), ages } a = 1, 2, 3 \dots 8, \text{ time } t = 1973.29, 1974.29 \dots 1981.29$

$s = \text{NMFS fall, ages } a = 0, 1, 2 \dots 5, \text{ time } t = 1969.69, 1970.69 \dots 2002.69$

A catch of 0 was assumed for the 1st quarter of 2003 and the population was calculated to the beginning of 2003.25. The NMFS spring survey in 2003 was designated as occurring at time 2003.25 instead of 2003.29. The NMFS fall survey captures young of the year and that information is included as 0 group, but older haddock appear less available during this season. Survey indices for older ages where catches were sparse and where there were frequent occurrences of zero catches were not included. Zero observations for abundance indices were treated as missing data as the logarithm of zero is not defined. During years when discarding was high, survey information was used along with interviews to obtain estimates of the USA catch. This lack of complete independence between catch and survey data does not influence population estimates but may deflate variance estimates marginally.

Statistical properties of estimators were obtained from model conditioned non-parametric bootstrap of the residuals (Efron and Tibshirani 1993) as described in Gavaris and Van Eeckhaute (1998). The population abundance estimates show a large relative error and substantial bias at ages 1 while the relative error for other ages is between about 27% and 41% and the bias is smaller (Table 17). The average magnitude of residuals is large and though several large residuals can be identified, the respective observations do not appear influential and should not impact parameter estimates of current abundance (Figures 22-26). Some patterns in the residuals (by cohort and by age) merit further investigation.

Retrospective Analysis

Assessment results for several other stocks have identified a discrepancy between past and current estimates of stock status (retrospective pattern). This stock assessment does not suffer from a retrospective pattern. Successive estimates of year-class abundance at age are fairly stable (Figure 27) although there is sometimes a substantial change after the first estimate of a year-class when more data becomes available, as evidenced for the 1998 and

2000 year-classes. There were no trends of concern for adult biomass (ages 3-8) or for F (ages 4-8 weighted by population numbers) in the retrospective patterns (Figure 28).

Stock Status

The results from the calibrated VPA were considered appropriate on which to base the status of the stock. For each cohort, the terminal population abundance estimates from ADAPT were adjusted for bias estimated from the bootstrap, and used to construct the history of stock status (Tables 18-19). This approach for bias adjustment, in the absence of an unbiased point estimator with optimal statistical properties, was considered preferable to using the biased point estimates (O'Boyle 1998). The weights at age from the DFO spring survey (Table 16) were used to calculate beginning of year population biomass (Table 20). A weight of 2.4 kg, which was midway between the age 6 and 8 weight for that cohort, was used for age 7 in 1995 as no data were available for that age group. For 1969-85, the 1986-95 average weight at each age was used.

Population biomass (ages 3+) has steadily increased from near an historical low of about 10,000 t in 1993 to about 78,000 t at the beginning of 2003 (Figure 29). Biomass is at the highest it has been in about 30 years and is now at the lower range of the 1930-1955 biomass. The recent increase has been due to more consistent and improved recruitment and was enhanced by increased survivorship and by reduced capture of small fish in the fisheries. Since the 1991 year-class, only the 2001 and 2002 year-classes have been below 4 million fish. Between the 1978 and 1991 year-classes, 7 of the 14 year-classes were below 4 million fish. The biomass increase is expected to be sustained by the 2000 year-class. Total biomass (ages 1+) trend is similar to the ages 3+ trend.

Population biomass during the late 1970s and early 1980s was about 50,000 t, due to recruitment of the strong 1975 and 1978 year-classes whose abundance was estimated at about 50 million. However, biomass declined rapidly in the early 1980s as subsequent recruitment was poor and these two year-classes were fished intensely at a young age.

Recruitment, estimated by the VPA, indicate that the 2000 year-class (77 million at age 1) is estimated to be larger than the good 1975 and 1978 year-classes (Figure 30). The 1998 year-class (29 million at age 1) is the second strongest since that of 1978. The 1996 and 1999 year-classes were estimated to be about 13 million, comparable to the 1983, 1985 and 1987 year-classes, which were the strongest 3 year-classes over about a 20 year time span.

Since 1995, fishing mortality rate on fully recruited ages 4+ has consistently been below that corresponding to the fishing mortality threshold reference established at $F_{ref} = 0.26$ ($F_{2002} = 0.19$; 80% Confidence Interval: 0.15 – 0.23), (exploitation rate = 0.21) (Figure 31). Historically, the fishing mortality rate has generally exceeded that corresponding to F_{ref} and showed a marked increase between 1989 and 1993 to about 0.6 (41%), the highest observed. Reduced fishing mortality in recent years has resulted in increased survival of incoming year-classes. The number of haddock of the 1992 year-class surviving to age 8 was about four times that of the equally abundant 1983 year-class, and about the same as that of the 1975 or 1978 year-classes, which were more than 3 times as abundant (Figure 32). Fishery avoidance of small fish has resulted in the number of fish of the 1998 year-class surviving to age 3 to be almost as many as survived to age 3 of the 1978 year-class

which was twice as strong. In both absolute numbers and percent composition, the population structure displays a broad representation of age groups, reflecting improving recruitment and lower exploitation since 1995 (Figure 33).

Gains in fishable biomass may be partitioned into those associated with somatic growth of haddock, which have previously recruited to the fishery, and those associated with new recruitment to the fishery (Rivard 1980). We used age 2 as a convenient age of first recruitment to the fishery. Except for 1996, since 1993 surplus production (biomass gains from growth and from recruitment, decremented by losses due to natural deaths) has exceeded the fishery harvest yield, resulting in net increase (Figure 34). Growth of fish is the dominant component of the biomass gain but recruitment accounts for significant portions when stronger year-classes enter the population. (Figure 35).

Prognosis

The risk analysis is provided in terms of the possible consequences for alternative catch quotas in 2004 with respect to the harvest reference points. Uncertainty about year-class abundance generates uncertainty in forecast results. This uncertainty is expressed as the risk of exceeding $F_{ref} = 0.26$, the risk of not achieving a biomass increase and the risk that the biomass will decline below the median 2005 rebuilding biomass of 65,000 t.

Forecasts were done starting with population estimates at the beginning of the second quarter in 2003. The abundance of the 2003 and 2004 year-classes were assumed to be 10 million at age 0. For the forecast, partial recruitment to the fishery for ages 1, 2 and 3 and fishery weights at age were averaged over 1998 to 2002 while beginning of year population weights were those observed in 2003 (Table 21). With an assumed total catch of 8,000 t in 2003 and natural mortality assumed to be 0.2, a combined Canada/USA catch of 8,000 t in 2004 would result in a low probability that the fishing mortality rate in 2004 will exceed F_{ref} (Figure 37). At this yield, there is a negligible probability of achieving a 10% biomass increase from 2004 to 2005, due to the 2 weak incoming year-classes, but there is a low probability that the biomass will fall below the median 2005 rebuilding biomass of 65,000 t (25% and 75% quartiles: 59,000 t – 76,000 t). The 2000 year-class (age 4) is expected to comprise the highest proportion of the total 2004 yield, accounting for about 60%.

These uncertainties are dependent on the model assumptions and data used in the analyses. Though these assumptions were deemed most suitable, there may be other plausible assumptions. These calculations do not include uncertainty due to variations in weight at age, partial recruitment to the fishery, natural mortality, systematic errors in data reporting or the possibility that the model may not reflect the stock dynamics closely enough. The risk profiles provide a general sense of the associated uncertainties and can assist in assessing the consequences of alternative actions.

Management Considerations

Consistent management by Canada and the USA is required to ensure that conservation objectives are not compromised.

Recruitment of the strong 2000 year-class resulted in almost a doubling of the biomass for ages 3+ by the beginning of 2003. However, due to the subsequent weak incoming year-classes, a TAC greater than 8,000 t in 2004 has a greater than 50% chance of decreasing the adult biomass.

Data were available to approximate the age composition of the catch from unit areas 5Zj and 5Zm in order to reconstruct an illustrative population analysis for the period between 1930 and 1955 suitable for comparison of productivity. Total catches during the 1930s to 1950s ranged between 15,000 t and 40,000 t, averaging about 25,000 t. Catches probably attained record high levels of about 60,000 t during the early 1960s. Since the early 1970s, catches have been substantially lower, generally fluctuating between 5,000 t and 10,000 t. Although biomass has been increasing and is the highest it has been in about 30 years, sitting at the lower range of the 1930-55 levels, it remains below the average biomass during those years (Figure 38).

The pattern of recruitment indicates that the chance of a good year-class is significantly enhanced for adult biomass above about 40,000 t (Figure 39). Since 1969, only the 1975, 1978 and 2000 year-classes have been above the average abundance of year-classes observed during the period 1930-55. Examination of the recruits per adult biomass ratio suggests that survivorship to age 1, for several years during the 1980s, may have been lower than the norm (Figure 40). Except for the 2001 and 2002 year-classes, the present survivorship appears comparable to that of the 1930s to 1950s period, suggesting that higher recruitment might result if the biomass increases.

Fishing mortality rate and biomass can be used to compare consequences of alternative harvest yields. The projections above show those results. Other attributes like recruitment, age structure and spatial distribution reflect possible fluctuations in the productive potential and can be used to qualify reference points and acceptable risk. While conditions have improved, maintaining fishing mortality rate at current levels would enhance further rebuilding.

Cod and haddock are often caught together in Canadian groundfish fisheries. However, their catchabilities to the fisheries differ and they are not necessarily caught in proportion to their relative abundance. With current fishing practices, exploitation of haddock at F_{ref} may compromise the achievement of rebuilding objectives for cod.

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Table 1. Nominal catches (t) of haddock from unit areas 5Zjm. For "Other" it was assumed that 40% of the total 5Z catch was in 5Zjm.

Year	Landings			Discards		Total
	Canada	USA	Other	Canada	USA	
1969	3941	6622	695			11258
1970	1970	3153	357			5480
1971	1610	3534	770			5914
1972	609	1551	502			2662
1973	1565	1396	396			3357
1974	462	955	573		757	2747
1975	1353	1705	29			3087
1976	1355	973	24			2352
1977	2871	2429			2966	8266
1978	9968	4724			1556	16248
1979	5080	5211				10291
1980	10017	5615			7561	23193
1981	5658	9077				14735
1982	4872	6280				11152
1983	3208	4454				7662
1984	1463	5121				6584
1985	3484	1683				5167
1986	3415	2200				5615
1987	4703	1418				6121
1988	4046*	1693				5739
1989	3060	787				3847
1990	3340	1189				4529
1991	5456	949				6405
1992	4058	1629				5687
1993	3727	421				4148
1994	2411	33			258	2702
1995	2065	22			25	2112
1996	3663	36			41	3740
1997	2749	48			63	2859
1998	3371	311			14	3696
1999	3681	355				4036
2000	5402	187				5589
2001	6774	604		22		7400
2002	6499	945		19		7462

* 1895 t excluded because of suspected area misreporting.

Table 2. Regulatory measures implemented for the 5Z and 5Zjm fishery management units by the USA and Canada, respectively, from 1977, when jurisdiction was extended to 200 miles for coastal states, to the present.

	USA	Canada
1977-82	Mesh size of 5 1/8" (140 mm), seasonal spawning closures, quotas and trip limits.	
1982-85	All catch controls eliminated, retained closed area and mesh size regulations, implemented minimum landings size (43 cm).	First 5Ze assessment in 1983.
1984 Oct.	Implementation of the 'Hague' line .	
1985	5 1/2" mesh size., Areas 1 and 2 closed during February-May.	
1989		Combined cod-haddock-pollock quota for 4X-5Zc
1990		5Zjm adopted as management unit. For MG < 65 ft. - trip limits with a 30% by-catch of haddock to a maximum of 8 trips of 35,000 lbs per trip between June 1 and Oct. 31 and 130 mm square mesh required. Fixed gear required to use large hooks until June
1991	Established overfishing definitions for haddock.	MG < 65 ft similar to 1990 but mesh size increased to 145 mm diamond.
1992		Introduction of ITQs and dockside monitoring.
1993	Area 2 closure in effect from Jan 1-June30.	OT fishery permitted to operate in Jan. and Feb. Increase in use square mesh.
1994	Jan.: Expanded Area 2 closure to include June and increased extent of area. Area 1 closure not in effect. 500 lb trip limit. Catch data obtained from mandatory log books combined with dealer reports (replaces interview system). May: 6" mesh restriction. Dec.: Area 1,2 closed year-round.	Spawning closure extended to Jan. 1 to May 31. Fixed gear vessels must choose between 5Z or 4X for the period of June to September. Small fish protocol. Increased at sea monitoring. OT > 65 could not begin fishing until July 1. Predominantly square mesh by end of year.
1995		All OT vessels using square mesh. Fixed gear vessels with a history since 1990 of 25t or more for 3 years of cod, haddock pollock, hake or cusk combined can participate in 5Z fishery. ITQ vessel require at least 2t of cod and 8t of haddock quota to fish Georges.
1996	July: Additional Days-at-Sea restrictions, trip limit raised to 1000 lbs.	Fixed gear history requirement dropped.
1997	May: Additional scheduled Days-at-sea restrictions. September: Trip limit raised to 1000 lbs/day, maximum of 10,000 lbs/trip.	Vessels over 65 ft operated on enterprise allocations, otter trawlers under 65 ft on individual quotas, fixed gear vessels 45-65 ft on self-administered individual quotas and fixed gear vessels under 45 ft on community quotas administered by local boards.
1998	Sept. 1: Trip limit raised to 3000 lbs/day, maximum of 30,000 lbs/trip.	Fixed gear vessels 45-65 ft operated on individual quotas.
1999	May 1: Trip limit 2,000 lbs/day, max. 20,000 lbs/trip. Square mesh size increased to 6.5" (diamond is 6"). June 15: Scallop exemption fishery in Closed Area II. Nov. 5: Trip limit 5,000 lbs/day, max. 50,000 lbs/trip.	Same as 1997 and 1998.
2000	October: Daily trip limit suspended to April 2001 but retained max. trip limit of 50,000 lbs/trip.	Same as 1999.
2001	Max. trip limit 50,000 lbs/trip; daily limit 5,000 lbs November: Daily limit suspended through April 2002	Same as 2000.
2002	Max. trip limit 50,000 lbs/trip; daily limit 5,000 lbs July: Daily limit suspended through April 2003	Same as 2001.

Table 3. Canadian landings (t) of haddock in unit areas 5Zjm by gear category and tonnage class for principle gears.

Year	Side	Otter Trawl					Longline			Other	Total
		Stern									
		2	3	4	5	Total ¹	2	3	Total ¹		
1969	777	0	1	225	2902	3127	2	21	23	15	3941
1970	575	2	0	133	1179	1314	6	72	78	2	1970
1971	501	0	0	16	939	955	18	129	151	3	1610
1972	148	0	0	2	260	263	23	169	195	3	609
1973	633	0	0	60	766	826	23	80	105	0	1565
1974	27	0	6	8	332	346	29	59	88	1	462
1975	222	0	1	60	963	1024	25	81	107	0	1353
1976	217	0	2	59	905	967	48	108	156	15	1355
1977	370	92	243	18	2025	2378	43	51	94	28	2871
1978	2456	237	812	351	5639	7039	121	47	169	305	9968
1979	1622	136	858	627	1564	3185	190	80	271	2	5080
1980	1444	354	359	950	6254	7917	129	51	587	69	10017
1981	478	448	629	737	2344	4159	331	99	1019	2	5658
1982	115	189	318	187	3341	4045	497	187	712	0	4872
1983	106	615	431	107	1130	2283	593	195	815	4	3208
1984	5	180	269	21	149	620	614	192	835	3	1463
1985	72	840	1401	155	348	2745	562	33	626	41	3484
1986	51	829	1378	95	432	2734	475	98	594	35	3415
1987	48	782	1448	49	1241	3521	854	113	1046	89	4703
1988 ²	72	1091	1456	186	398	3183	428	200	695	97	4046
1989	0	489	573	376	536	1976	713	175	977	106	3060
1990	0	928	890	116	471	2411	623	173	853	76	3340
1991	0	1610	1647	81	689	4028	900	271	1309	119	5456
1992	0	797	1084	56	645	2583	984	245	1384	90	4058
1993	0	535	1179	67	699	2489	794	156	1143	96	3727
1994	0	495	911	79	112	1597	498	47	714	100	2411
1995	0	523	896	14	214	1647	256	75	390	28	2065
1996	1	836	1405	166	270	2689	561	107	947	26	3663
1997	0	680	1123	91	96	1991	501	116	722	36	2749
1998	0	863	1340	98	71	2422	570	252	921	27	3371
1999	0	954	1471	174	145	2761	486	241	887	33	3680
2000	0	1313	2269	230	246	4146	619	258	1186	71	5402
2001	0	1564	2555	0	757	5112	754	302	1633	29	6774
2002	0	1217	2727	0	659	4960	891	151	1527	12	6499

¹ Total includes catches for tonnage classes which are not listed, only tonnage classes with substantial catches listed

² Catches of 26t, 776t, 1091t and 2t for side otter trawlers and stern otter trawlers tonnage classes 2, 3 and 5 respectively were excluded because of suspected area misreporting.

Table 4. Monthly landings (t) of haddock by Canada in unit areas 5Zjm.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	105	74	6	291	588	691	559	580	551	360	102	34	3941
1970	2	105	0	1	574	345	103	456	242	103	26	12	1970
1971	0	9	1	0	400	132	283	278	97	246	141	21	1610
1972	0	119	2	0	2	111	84	116	98	68	7	2	609
1973	4	10	0	0	0	184	198	572	339	232	22	4	1565
1974	19	0	1	0	0	58	63	53	96	61	92	19	462
1975	4	14	0	0	0	166	256	482	100	166	118	45	1353
1976	0	7	62	68	60	587	152	190	186	26	9	7	1355
1977	102	177	7	0	23	519	1059	835	13	59	56	22	2871
1978	104	932	44	22	21	319	405	85	642	5433	1962	0	9968
1979	123	898	400	175	69	1393	885	396	406	261	53	22	5080
1980	38	134	14	29	223	2956	2300	965	1411	1668	104	176	10017
1981	38	481	568	4	254	1357	1241	726	292	82	378	239	5658
1982	129	309	1	11	46	1060	769	682	585	837	398	44	4872
1983	32	67	29	47	60	1288	387	483	526	195	88	6	3208
1984	3	5	81	88	73	433	219	254	211	71	25	0	1463
1985	1	11	33	99	26	354	392	1103	718	594	61	93	3484
1986	11	28	79	99	40	1339	1059	369	233	139	12	8	3415
1987	24	26	138	70	12	1762	1383	665	405	107	97	14	4703
1988 ¹	39	123	67	79	15	1816	1360	315	130	65	13	24	4046
1989	33	94	48	7	20	1398	356	566	141	272	108	18	3060
1990	35	14	50	0	7	1178	668	678	469	199	18	22	3340
1991	144	166	49	26	21	1938	1004	705	566	576	123	137	5456
1992	118	205	97	152	36	1381	619	414	398	401	209	28	4058
1993	468	690	96	78	25	723	505	329	202	198	230	183	3727
1994	3	3	1	2	0	398	693	373	375	220	211	133	2411
1995	5	1	1	1	0	762	327	290	281	109	197	93	2065
1996	0	0	0	0	0	1067	672	706	359	278	191	391	3663
1997	0	0	0	0	0	328	751	772	426	190	116	166	2749
1998	0	0	0	0	0	687	420	580	707	542	164	271	3371
1999	37	0	0	0	0	898	975	562	573	295	269	70	3681
2000	1	0	0	0	0	1368	1175	1026	848	658	175	150	5402
2001	0	0	0	0	0	971	1335	930	1267	1075	647	548	6774
2002	0	0	0	0	0	535	1619	1030	1352	870	555	537	6499

¹ Catches of 3t, 1846t and 46t for Jan., Feb., and Mar., respectively for otter trawlers were excluded because of suspected area misreporting

Table 5. USA landings (t) of haddock in unit areas 5Zjm by gear category and tonnage class. Details for 1994-2002 are not available because data are preliminary.

Year	Otter Trawl		Total	Other	Total
	3	4			
1969	3010	3610	6621	0	6622
1970	1602	1551	3154	0	3153
1971	1760	1768	3533	0	3534
1972	861	690	1551	0	1551
1973	637	759	1396	0	1396
1974	443	512	955	0	955
1975	993	675	1668	36	1705
1976	671	302	972	2	973
1977	1721	700	2423	5	2429
1978	3140	1573	4713	11	4724
1979	3281	1927	5208	4	5211
1980	3654	2955	5611	4	5615
1981	3591	5408	9031	45	9077
1982	2585	3657	6242	37	6280
1983	1162	3261	4423	29	4454
1984	1854	3260	5115	5	5121
1985	856	823	1679	4	1683
1986	985	1207	2192	9	2200
1987	778	639	1417	1	1418
1988	920	768	1688	6	1693
1989	359	419	780	6	787
1990	486	688	1178	4	1189
1991	400	517	918	13	931
1992	597	740	1337	292	1629
1993	142	191	333	88	421
1994			32	0	33
1995			21	0	22
1996			36	0	36
1997			48	0	48
1998			311	0	311
1999			355	0	355
2000			187	0	187
2001			602	2	604
2002			944	1	945

Table 6. Monthly landings (t) of haddock by USA in unit areas 5Zjm. Details for 1994-2002 are not available because data is preliminary.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	525	559	976	1825	670	809	204	219	249	226	203	157	6622
1970	169	219	242	375	608	374	324	333	179	219	61	50	3153
1971	155	361	436	483	668	503	338	152	147	165	58	68	3534
1972	150	196	91	90	239	261	97	164	84	63	52	64	1551
1973	90	111	77	85	138	365	217	196	37	3	22	55	1396
1974	135	70	47	70	122	160	165	43	27	6	19	91	955
1975	152	123	32	116	388	489	138	95	57	24	52	39	1705
1976	116	147	83	106	323	162	7	6	5	2	3	13	973
1977	75	211	121	154	374	372	434	191	73	52	146	226	2429
1978	336	437	263	584	752	750	467	221	245	426	194	49	4724
1979	274	329	352	548	766	816	588	659	224	202	281	172	5211
1980	632	1063	742	784	711	461	324	254	221	91	110	222	5615
1981	550	1850	634	627	882	1326	1233	873	321	284	242	255	9077
1982	425	754	502	347	718	1801	757	145	201	216	276	138	6280
1983	492	931	272	181	310	1145	231	178	187	110	227	190	4454
1984	540	961	366	281	627	1047	370	302	250	196	92	89	5121
1985	165	190	254	300	352	206	60	47	1	24	41	43	1683
1986	184	396	334	479	496	221	31	6	12	6	6	29	2200
1987	225	52	43	307	233	342	67	30	24	4	23	68	1418
1988	196	152	207	245	366	316	30	19	6	1	45	110	1693
1989	114	56	47	164	161	145	15	8	1	5	25	46	787
1990	148	21	155	274	214	306	23	3	5	5	16	19	1189
1991	105	28	76	133	89	434	1	20	6	0	19	19	931
1992	253	81	51	149	353	669	20	20	17	3	2	12	1629
1993	15	12	16	55	84	209	6	3	3	7	2	8	421
1994													33
1995													22
1996													36
1997													48
1998													311
1999													355
2000													187
2001													604
2002													945

Table 7. USA landings of haddock in 2002 by quarter and market category from unit areas 5Zjm and sampling intensity for lengths and ages.

Market category	Large	Scrod	Unclassified	Total
Landings (t)				
Quarter 1	96	68	1	165
Quarter 2	291	300	14	605
Quarter 3	56	43	0	99
Quarter 4	48	27	1	76
Total	491	438	16	945

Lengths per 100 t (Number measured)				
Quarter 1	94 (91)	0 (0)	NA	55 (91)
Quarter 2	87 (258)	43 (131)	NA	64 (389)
Quarter 3	274 (153)	0 (0)	NA	155 (153)
Quarter 4	0 (0)	0 (0)	NA	0 (0)
Total	102 (502)	30 (131)	NA	67 (633)

Ages per 100 t (Number aged)				
Quarter 1	38 (37)	0 (0)	NA	22 (36)
Quarter 2	26 (74)	16 (48)	NA	21 (127)
Quarter 3	64 (36)	0 (0)	NA	36 (36)
Quarter 4	0 (0)	0 (0)	NA	0 (0)
Total	30 (147)	11 (48)	NA	21 (199)

Table 8. Sampling for landings of the 2002 5Zjm Canadian haddock fishery.

Qtr.	Gear	Month	Landings (kg)	Length Frequency Samples				Ages			
				Observer		Port					
				Trips	Measure d	Samples	Measure d	Observe r	Port		
2	OT IN OF OF LL IN GN IN	June June June June	472,408 58,579 3,3613 227	11	5881	6 2	1326 400	116	215		
3	OT IN	July	1,170,046	9	6132	7	1651	4	454		
		Aug	517,108	5	2832	3	730				
		Sept	732,638	3	880	9	2038				
	OT OF	July	150,706	1	795	3	600				
		Aug	53,855			1	200				
		Sept	251,285	1	1600						
	LL IN	July	292,386	3	3157	1	220				
		Aug	456,196	5	4,581	5	1200				
		Sept	365,904	1	1165	3	699				
	Handlin e	July	2	Added to Q3 LL IN							
		Aug	3								
	GN IN	July	6,328	GN IN Dec							
		Aug	2,783								
		Sept	1,973								
4	OT IN	Oct	621,451	2	734	9	1986	7	503		
		Nov	392,058			5	1211				
		Dec	394,441	3	1048	2	714				
	OT OF	Oct	18,092								
		Nov	58,405			2	400				
		Dec	68,435			1	200				
	LL IN	Oct	230,178	1	1148	7	1668				
		Nov	104,153			2	481				
		Dec	74,368	1	817	1	240				
	GN IN	Oct	319								
		Nov	483								
		Dec	150			1	68				
Totals			6,498,573	46	30770	70	16032	127	1172		

OT=Otter Trawl Bottom, GN=Gill Net, LL=Longline, IN=Tonnage Class 0-3, OF=Tonnage Class 4-6

Table 9. Components of catch at age numbers of haddock from unit areas 5Zjm by quarter. Discards from the Canadian scallop fishery are not included.

Quarter	Age Group									
	1	2	3	4	5	6	7	8	9+	1+
Canada										
2001	0	0	0	0	0	0	0	0	0	0
2001.25	0	9962	291307	98979	117781	36310	27329	17640	10391	609699
2001.5	1726	24708	864109	258352	375614	102998	105214	89418	82723	1904863
2001.75	362	25523	471899	125224	261714	84241	44897	90244	58151	1162255
Year total	2088	60194	1627314	482555	755109	223548	177440	197302	151265	3676816
USA										
2001	0	0	13197	16828	13158	14463	7960	6180	5173	76959
2001.25	0	0	24527	31274	24453	26879	14793	11486	9614	143026
2001.5	0	0	5162	6583	5147	5658	3114	2418	2023	30104
2001.75	0	0	5371	6849	5355	5886	3239	2515	2105	31321
Year total	0	0	48258	61533	48112	52886	29105	22599	18915	281409
Total										
2001	0	0	13197	16828	13158	14463	7960	6180	5173	76959
2001.25	0	9962	315834	130253	142234	63189	42122	29126	20005	752724
2001.5	1726	24708	869271	264935	380761	108656	108328	91835	84746	1934967
2001.75	362	25523	477270	132072	267069	90127	48136	92760	60256	1193575
Year total	2088	60194	1675572	544088	803222	276435	206546	219901	170180	3958225
Canada										
2002	0	0	0	0	0	0	0	0	0	0
2002.25	0	14178	10443	157663	42055	40913	6004	4987	13655	289897
2002.5	305	154290	130570	1007299	152606	368946	50520	60827	154784	2080146
2002.75	208	111201	51107	505302	120997	173254	26673	17675	48881	1055298
Year total	513	279669	192120	1670264	315658	583112	83196	83490	217319	3425341
USA										
2002	0	0	3200	25300	9900	12800	4600	3600	17200	76800
2002.25	0	4400	7300	125900	38600	46200	19700	15000	33300	290500
2002.5	0	400	1400	19200	3100	9700	1500	2300	7000	44500
2002.75	0	1000	1100	14200	3700	8300	1700	1200	3600	34700
Year total	0	5800	13000	184600	55300	77000	27500	22100	61100	446500
Total										
2002	0	0	3200	25300	9900	12800	4600	3600	17200	76800
2002.25	0	18578	17743	283563	80655	87113	25704	19987	46955	580397
2002.5	305	154690	131970	1026499	155706	378646	52020	63127	161784	2124646
2002.75	208	112201	52207	519502	124697	181554	28373	18875	52481	1089998
Year total	513	285469	205120	1854864	370958	660112	110696	105590	278419	3871841

Table 10. Total annual commercial catch at age numbers (000's) of haddock from unit areas 5Zjm.

Year	Age Group										
	0	1	2	3	4	5	6	7	8	9+	1+
1969	0	0	18	1441	260	331	2885	819	89	279	6123
1970	0	25	82	7	347	147	126	1140	364	189	2425
1971	0	0	1182	247	31	246	157	159	756	407	3185
1972	0	259	1	376	71	21	92	37	16	431	1303
1973	0	1015	1722	6	358	37	10	37	8	163	3358
1974	0	17	2105	247	0	31	3	0	29	57	2488
1975	0	0	270	1428	201	5	34	1	2	28	1969
1976	0	73	149	166	814	125	0	19	0	17	1363
1977	0	0	7836	64	178	303	162	0	15	14	8571
1978	0	1	285	9831	161	169	302	80	10	9	10848
1979	0	0	15	199	4250	362	201	215	43	14	5300
1980	0	3	17561	342	299	2407	191	129	51	12	20995
1981	0	0	660	6687	393	494	1234	119	33	7	9627
1982	0	0	713	1048	2799	201	377	723	62	65	5988
1983	0	0	140	648	546	1629	207	104	402	34	3710
1984	0	0	76	249	341	264	1120	186	165	314	2716
1985	0	0	2063	374	176	189	123	371	53	114	3463
1986	0	6	38	2557	173	142	122	118	173	41	3369
1987	0	0	1990	127	1515	96	56	82	68	108	4042
1988	0	4	51	2145	121	877	109	36	46	98	3487
1989	0	0	1153	78	734	129	320	31	20	45	2510
1990	0	2	7	1265	126	743	68	163	42	42	2457
1991	0	6	441	89	2041	88	389	72	145	61	3332
1992	0	7	230	311	127	1446	89	315	26	90	2640
1993	0	7	247	343	279	85	635	34	153	74	1856
1994	0	1	241	737	148	54	48	125	29	39	1423
1995	0	2	60	525	414	53	25	3	51	16	1149
1996	0	1	29	481	862	419	61	18	3	72	1946
1997	0	2	81	80	542	483	194	13	8	34	1438
1998	0	1	163	282	258	539	446	114	12	35	1851
1999	0	1	35	737	315	244	344	253	97	25	2052
2000	0	0	309	437	1245	249	200	209	182	65	2896
2001	0	2	60	1676	544	803	276	207	220	170	3958
2002	0	1	285	205	1855	371	660	111	106	278	3872

Table 11. Average weight at age (kg) of haddock from the commercial fishery in unit areas 5Zjm. The 1989 to 1991 year-classes (shaded) grew faster than adjacent year-classes.

Year	Age Group							
	1	2	3	4	5	6	7	8
1969	0.600	0.763	1.282	1.531	1.649	1.836	2.298	2.879
1970	0.721	1.067	0.812	1.653	1.886	2.124	2.199	2.841
1971	0.600	0.928	1.059	1.272	2.011	2.255	2.262	2.613
1972	0.759	1.000	1.562	1.750	2.147	2.505	2.411	2.514
1973	0.683	1.002	1.367	1.804	2.202	1.631	2.885	3.295
1974	0.600	0.970	1.418	1.800	1.984	3.760	2.700	3.128
1975	0.600	0.872	1.524	2.062	1.997	2.422	4.114	3.557
1976	0.596	0.956	1.293	1.857	2.417	2.700	2.702	3.000
1977	0.600	0.970	1.442	1.809	2.337	2.809	2.700	3.095
1978	0.619	1.151	1.433	2.055	2.623	2.919	2.972	2.829
1979	0.600	0.987	1.298	1.805	2.206	2.806	3.219	3.277
1980	0.405	0.892	1.034	1.705	2.115	2.593	3.535	3.608
1981	0.600	0.890	1.262	1.592	2.270	2.611	3.505	4.009
1982	0.600	0.965	1.363	1.786	2.327	2.557	2.958	3.531
1983	0.600	1.024	1.341	1.750	2.118	2.509	2.879	3.104
1984	0.600	0.876	1.354	1.838	2.159	2.605	2.856	3.134
1985	0.600	0.950	1.230	1.915	2.227	2.702	2.872	3.180
1986	0.452	0.981	1.352	1.866	2.367	2.712	2.969	3.570
1987	0.600	0.833	1.431	1.984	2.148	2.594	2.953	3.646
1988	0.421	0.974	1.305	1.708	2.042	2.350	3.011	3.305
1989	0.600	0.868	1.450	1.777	2.183	2.522	3.012	3.411
1990	0.639	0.999	1.419	1.787	2.141	2.509	2.807	3.002
1991	0.581	1.197	1.241	1.802	2.087	2.596	2.918	3.012
1992	0.538	1.163	1.622	1.654	2.171	2.491	2.988	3.388
1993	0.659	1.160	1.724	2.181	2.047	2.623	2.386	3.112
1994	0.405	1.135	1.661	2.235	2.639	2.422	2.831	3.223
1995	0.797	1.055	1.511	2.033	2.550	2.755	2.908	3.010
1996	0.576	1.022	1.439	1.795	2.294	2.485	3.322	2.032
1997	0.685	1.215	1.336	1.747	2.120	2.476	3.034	3.365
1998	0.568	1.131	1.573	1.697	1.983	2.312	2.864	3.395
1999	0.678	1.095	1.570	1.910	1.865	2.182	2.535	2.773
2000	0.664	1.103	1.470	1.920	2.242	2.098	2.497	2.816
2001	0.394	1.102	1.471	1.755	2.107	2.367	2.186	2.522
2002	0.405	1.009	1.418	1.763	1.941	2.343	2.660	2.382
Low	0.394	0.763	0.812	1.272	1.649	1.631	2.186	2.032
High	0.797	1.215	1.724	2.235	2.639	3.760	4.114	4.009
Median	0.600	1.000	1.418	1.798	2.148	2.509	2.876	3.120
Average	0.590	1.009	1.384	1.812	2.165	2.505	2.851	3.105

Table 12. Conversion factors used to adjust for changes in door type and survey vessel in the NMFS surveys.

Year	Door	Spring		Fall	
		Vessel	Conversion	Vessel	Conversion
1968	BMV	Albatross IV	1.49	Albatross IV	1.49
1969	BMV	Albatross IV	1.49	Albatross IV	1.49
1970	BMV	Albatross IV	1.49	Albatross IV	1.49
1971	BMV	Albatross IV	1.49	Albatross IV	1.49
1972	BMV	Albatross IV	1.49	Albatross IV	1.49
1973	BMV	Albatross IV	1.49	Albatross IV	1.49
1974	BMV	Albatross IV	1.49	Albatross IV	1.49
1975	BMV	Albatross IV	1.49	Albatross IV	1.49
1976	BMV	Albatross IV	1.49	Albatross IV	1.49
1977	BMV	Albatross IV	1.49	Delaware II	1.2218
1978	BMV	Albatross IV	1.49	Delaware II	1.2218
1979	BMV	Albatross IV	1.49	Delaware II	1.2218
1980	BMV	Albatross IV	1.49	Delaware II	1.2218
1981	BMV	Delaware II	1.2218	Delaware II	1.2218
1982	BMV	Delaware II	1.2218	Albatross IV	1.49
1983	BMV	Albatross IV	1.49	Albatross IV	1.49
1984	BMV	Albatross IV	1.49	Albatross IV	1.49
1985	Polyvalent	Albatross IV	1	Albatross IV	1
1986	Polyvalent	Albatross IV	1	Albatross IV	1
1987	Polyvalent	Albatross IV	1	Albatross IV	1
1988	Polyvalent	Albatross IV	1	Albatross IV	1
1989	Polyvalent	Delaware II	0.82	Delaware II	0.82
1990	Polyvalent	Delaware II	0.82	Delaware II	0.82
1991	Polyvalent	Delaware II	0.82	Delaware II	0.82
1992	Polyvalent	Albatross IV	1	Albatross IV	1
1993	Polyvalent	Albatross IV	1	Delaware II	0.82
1994	Polyvalent	Delaware II	0.82	Albatross IV	1
1995	Polyvalent	Albatross IV	1	Albatross IV	1
1996	Polyvalent	Albatross IV	1	Albatross IV	1
1997	Polyvalent	Albatross IV	1	Albatross IV	1
1998	Polyvalent	Albatross IV	1	Albatross IV	1
1999	Polyvalent	Albatross IV	1	Albatross IV	1
2000	Polyvalent	Albatross IV	1	Albatross IV	1
2001	Polyvalent	Albatross IV	1	Albatross IV	1
2002	Polyvalent	Albatross IV	1	Albatross IV	1
2003	Polyvalent	Delaware II	0.82		

Table 13. Total estimated abundance at age (numbers in 000's) of haddock for unit areas 5Zjm from DFO spring surveys.

Year	Age Group									Total
	1	2	3	4	5	6	7	8	9+	
1986	5057	306	8176	997	189	348	305	425	401	16205
1987	46	4286	929	3450	653	81	387	135	1132	11099
1988	971	49	12714	257	4345	274	244	130	686	19670
1989	48	6664	991	2910	245	526	40	34	265	11724
1990	726	108	12300	168	4466	299	1370	144	389	19968
1991	383	2163	134	10819	114	1909	117	505	225	16368
1992	1914	3879	1423	221	4810	18	1277	52	656	14249
1993	3448	1759	545	431	34	1186	19	281	147	7849
1994	4197	15163	5332	549	314	20	915	18	356	26864
1995	1231	3224	6236	3034	720	398	0	729	849	16422
1996	1455	2290	4784	5305	3113	303	274	38	684	18247
1997	1033	1550	1222	2742	2559	1397	150	65	372	11090
1998	2379	10626	5348	3190	5312	5028	2248	348	601	35080
1999	24593	4787	10067	3104	1963	1880	1764	448	174	48780
2000	3177	15865	7679	12108	2900	2074	2726	1591	813	48932
2001	23026	3519	14633	4255	5608	1808	1426	1963	2299	58536
2002	732	28174	5977	12659	2980	2644	647	528	2420	56760
2003	1682	1503	82161	5533	15105	3675	2355	1106	1986	115107

Table 14. Total estimated abundance at age (numbers in 000's) of haddock for unit areas 5Zjm from NMFS spring surveys. From 1973-81, a 41 Yankee trawl was used while a 36 Yankee trawl was used in other years. Conversion factors to adjust for changes in door type and survey vessel were applied.

Year	Age Group									Total
	1	2	3	4	5	6	7	8	9+	
1968	0	3254	68	679	4853	2045	240	123	234	11496
1969	17	35	614	235	523	3232	1220	358	489	6724
1970	478	190	0	560	998	441	3165	2491	769	9092
1971	0	655	261	0	144	102	58	1159	271	2650
1972	2594	0	771	132	25	47	211	27	1214	5020
1973	2455	5639	0	1032	154	0	276	0	1208	10763
1974	1323	20596	4084	0	354	0	43	72	322	26795
1975	528	567	6016	1063	0	218	127	45	208	8773
1976	8228	402	424	1127	532	0	0	0	22	10735
1977	126	26003	262	912	732	568	0	22	102	28727
1978	0	743	20859	641	880	1163	89	23	116	24516
1979	10496	441	1313	9764	475	72	445	42	9	23056
1980	4355	66450	1108	1086	5761	613	371	693	360	80797
1981	3281	2823	27085	2906	751	2455	347	56	21	39725
1982	584	3703	1658	7802	767	455	697	0	0	15666
1983	238	770	686	359	2591	30	0	798	58	5529
1984	1366	1414	1046	910	847	1189	133	73	490	7469
1985	40	8911	1396	674	1496	588	1995	127	483	15709
1986	3334	280	3597	246	210	333	235	560	159	8953
1987	122	5480	144	1394	157	231	116	370	0	8013
1988	305	61	1868	235	611	203	218	178	0	3678
1989	84	6665	619	1343	267	791	58	92	47	9966
1990	1654	70	10338	598	1042	110	182	0	0	13995
1991	740	2071	432	3381	192	203	66	87	25	7198
1992	529	287	205	158	602	32	46	46	0	1905
1993	1870	1116	197	232	195	717	77	35	43	4480
1994	1025	4272	1487	269	184	118	278	28	84	7745
1995	921	2312	4184	1727	265	152	51	272	214	10099
1996	912	1365	3789	3190	1905	237	36	0	496	11931
1997	1635	1226	380	595	470	343	24	44	20	4736
1998	549	6046	2005	1281	1184	303	58	15	122	11562
1999	6286	1914	3655	661	1128	1062	468	476	46	15696
2000	2675	2131	3399	1624	636	564	438	305	165	11938
2001	10503	1186	3304	1232	374	294	113	20	20	17047
2002	231	40432	10938	4044	1492	473	287	229	236	58362
2003	125	1105	16915	2245	3773	476	200	82	286	25206

Table 15. Total estimated abundance at age (numbers in 000's) of haddock for unit areas 5Zjm from NMFS fall surveys. Conversion factors to adjust for changes in door type and survey vessel were applied.

Year	Age Group									Total
	0	1	2	3	4	5	6	7	8+	
1963	105993	40995	10314	3378	5040	4136	1477	451	276	172061
1964	1178	123976	46705	4358	807	1865	477	211	167	179742
1965	259	1503	51338	8538	479	302	142	148	208	62918
1966	9325	751	1742	20323	3631	671	138	133	84	36798
1967	0	3998	73	327	1844	675	141	88	88	7233
1968	55	113	800	28	37	2223	547	177	313	4293
1969	356	0	0	509	62	30	739	453	108	2257
1970	0	6400	336	16	415	337	500	902	578	9483
1971	2626	0	788	97	0	265	27	73	594	4471
1972	4747	2396	0	232	0	0	53	0	275	7702
1973	1223	16797	1598	0	168	0	0	8	16	19809
1974	151	234	961	169	0	6	0	0	70	1589
1975	30365	664	192	1042	239	0	0	0	28	32530
1976	738	121717	431	25	484	71	0	17	37	123521
1977	47	238	26323	445	125	211	84	4	4	27480
1978	14642	547	530	7706	56	42	94	0	0	23617
1979	1598	21605	14	335	1489	45	12	0	0	25098
1980	3556	2788	5829	0	101	1081	108	25	4	13492
1981	596	4617	2585	2748	89	136	318	0	15	11103
1982	62	0	673	465	2508	153	97	528	42	4527
1983	3609	444	236	501	289	402	17	12	86	5598
1984	45	3775	856	233	194	45	262	0	41	5451
1985	12148	381	1646	199	70	68	46	30	21	14611
1986	30	7471	109	961	52	50	72	24	23	8793
1987	508	0	843	28	152	38	22	0	0	1592
1988	122	3983	184	2348	155	400	142	140	38	7513
1989	167	83	2645	112	509	68	73	0	0	3656
1990	1217	1041	36	1456	65	196	24	5	0	4040
1991	705	331	267	52	289	25	10	0	0	1679
1992	3484	1052	172	110	0	95	0	18	18	4948
1993	652	6656	3601	585	0	87	96	30	0	11707
1994	625	782	927	419	96	32	0	24	0	2905
1995	892	1436	5993	3683	550	30	0	0	53	12637
1996	1742	453	570	2302	963	167	0	0	0	6196
1997	217	5738	3368	592	690	385	0	0	13	11004
1998	2566	2966	4214	1085	705	526	722	0	0	12784
1999	3268	1236	5364	5060	837	2825	148	1150	991	20879
2000	1368	5284	6226	3712	622	229	0	146	97	17684
2001	659	16626	1382	6939	3000	1586	306	127	58	30684
2002	172	1864	44602	6040	5120	1660	863	457	354	61131

Table 16. Average weight at age (kg) from DFO spring surveys used to represent beginning of year weights.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
1986	0.135	0.451	0.974	1.445	3.044	2.848	3.598	3.376	3.918
1987	0.150	0.500	0.716	1.672	2.012	2.550	3.148	3.151	3.629
1988	0.097	0.465	0.931	1.795	1.816	1.918	2.724	3.264	3.871
1989	0.062	0.474	0.650	1.392	1.995	2.527	2.158	2.859	3.141
1990	0.149	0.525	0.924	1.181	1.862	2.073	2.507	2.815	3.472
1991	0.120	0.685	0.800	1.512	1.695	2.434	2.105	3.122	3.432
1992	0.122	0.602	1.118	1.061	2.078	2.165	2.709	2.284	3.440
1993	0.122	0.481	1.227	1.803	1.274	2.332	2.343	2.739	3.280
1994	0.107	0.469	1.047	1.621	1.927	2.154	3.154	2.688	3.084
1995	0.086	0.493	0.963	1.556	2.222	2.445		2.991	3.184
1996	0.139	0.495	0.919	1.320	1.932	2.555	2.902	2.611	3.588
1997	0.132	0.506	0.782	1.205	1.664	2.176	2.454	2.577	3.158
1998	0.107	0.535	1.035	1.161	1.570	1.954	2.609	3.559	3.462
1999	0.130	0.474	0.911	1.290	1.259	1.869	2.131	2.722	2.992
2000	0.116	0.543	0.949	1.478	1.871	1.789	2.298	2.508	2.901
2001	0.093	0.524	1.005	1.371	1.798	2.165	2.250	2.593	2.928
2002	0.096	0.332	0.778	1.138	1.494	1.965	2.177	2.206	2.707
2003	0.080	0.369	0.846	1.063	1.477	1.645	2.208	2.229	2.487
Low	0.062	0.332	0.650	1.061	1.259	1.645	2.105	2.206	2.487
High	0.150	0.685	1.227	1.803	3.044	2.848	3.598	3.559	3.918
Median	0.118	0.494	0.927	1.382	1.839	2.165	2.454	2.730	3.232
Average	0.113	0.496	0.921	1.393	1.833	2.198	2.557	2.794	3.260

Table 17. Statistical properties of estimates of population abundance (numbers in 000's) at time 2003.25 and survey calibration constants (unitless, survey:population) for haddock in unit areas 5Zjm obtained from a bootstrap with 1000 replications.

Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
<u>Population Abundance (000's)</u>					
1	2109	1518	0.720	382	0.181
2	3087	1272	0.412	211	0.068
3	51176	16008	0.313	2488	0.049
4	7517	2186	0.291	324	0.043
5	9635	2742	0.285	256	0.027
6	2297	615	0.268	24	0.010
7	1129	445	0.394	32	0.028
8	480	180	0.376	21	0.044
<u>Survey Calibration Constants</u>					
<i>DFO Spring Survey</i>					
1	0.224	0.052	0.232	0.006	0.026
2	0.482	0.107	0.223	0.014	0.029
3	0.949	0.206	0.217	0.031	0.033
4	0.875	0.186	0.212	0.021	0.024
5	1.064	0.242	0.228	0.030	0.028
6	0.903	0.197	0.218	0.020	0.023
7	1.186	0.276	0.233	0.031	0.026
8	1.180	0.248	0.210	0.001	0.001
<i>NMFS Spring Survey - Yankee 36 - 1969-72/1982-2003</i>					
1	0.126	0.023	0.186	0.002	0.016
2	0.328	0.063	0.191	0.003	0.011
3	0.450	0.089	0.197	0.007	0.015
4	0.432	0.083	0.193	0.007	0.017
5	0.507	0.093	0.184	0.010	0.019
6	0.408	0.073	0.180	0.005	0.013
7	0.448	0.083	0.186	0.008	0.017
8	0.501	0.099	0.197	0.008	0.016
<i>NMFS Spring Survey - Yankee 41 - 1973-81</i>					
1	0.225	0.078	0.349	0.013	0.059
2	0.511	0.160	0.313	0.021	0.042
3	0.639	0.207	0.325	0.022	0.035
4	0.793	0.265	0.334	0.034	0.043
5	0.964	0.318	0.330	0.037	0.038
6	0.887	0.346	0.390	0.055	0.062
7	1.595	0.617	0.387	0.106	0.066
8	0.633	0.232	0.367	0.034	0.054
<i>NMFS Fall Survey</i>					
0	0.119	0.019	0.157	0.001	0.004
1	0.318	0.053	0.168	0.002	0.005
2	0.244	0.040	0.165	0.003	0.013
3	0.243	0.040	0.163	0.004	0.018
4	0.182	0.031	0.169	0.002	0.013
5	0.168	0.029	0.174	0.002	0.014

Table 18. Beginning of year population abundance (numbers in 000's) for haddock in unit areas 5Zjm from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2003.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
1969	768	189	4375	853	905	8990	3021	185	809	20095	19327	19138
1970	3349	629	138	2295	465	448	4796	1745	486	14351	11003	10374
1971	456	2715	439	107	1569	249	253	2904	1335	10027	9571	6857
1972	5375	373	1128	138	61	1064	64	67	2441	10711	5336	4963
1973	11030	4152	305	587	49	31	792	19	1661	18626	7596	3444
1974	3342	8121	1827	244	153	7	17	614	1224	15550	12208	4086
1975	3222	2718	4750	1279	200	99	4	14	1430	13715	10493	7775
1976	53927	2633	1972	2593	868	159	51	2	1156	63362	9435	6802
1977	5899	43960	2022	1467	1403	599	131	25	933	56438	50539	6579
1978	4205	4830	28838	1599	1043	885	349	107	759	42614	38409	33579
1979	51913	3437	3680	14522	1160	703	457	213	692	76776	24864	21427
1980	6635	42502	2799	2831	8088	625	400	185	690	64756	58120	15618
1981	5116	5423	18952	1988	2051	4507	342	216	661	39256	34140	28717
1982	1710	4188	3832	9539	1279	1239	2605	176	683	25252	23542	19353
1983	2529	1400	2766	2194	5287	864	679	1487	592	17798	15269	13869
1984	14879	2070	1015	1674	1305	2883	522	462	1318	26128	11249	9179
1985	1550	12182	1625	607	1064	835	1370	264	1034	20532	18982	6799
1986	13226	1266	8035	984	338	702	574	795	914	26833	13607	12341
1987	1272	10795	1001	4293	654	150	466	367	1212	20211	18939	8144
1988	14969	1042	7036	706	2153	449	73	308	1134	27870	12900	11858
1989	787	12222	807	3823	469	989	271	28	1053	20449	19662	7440
1990	2359	644	8959	589	2467	268	524	195	827	16832	14473	13829
1991	1793	1927	521	6188	370	1351	159	283	762	13353	11560	9633
1992	7622	1460	1174	347	3212	223	756	66	670	15530	7908	6448
1993	10366	6226	983	680	171	1334	105	337	500	20701	10335	4109
1994	11981	8474	4857	492	308	65	530	56	486	27250	15269	6795
1995	4730	9785	6707	3286	266	202	8	319	381	25684	20954	11168
1996	5104	3862	7947	5004	2310	169	143	4	512	25055	19951	16089
1997	12021	4170	3131	6058	3300	1502	82	100	353	30718	18697	14527
1998	9366	9817	3336	2489	4455	2253	1050	55	332	33153	23787	13970
1999	29117	7659	7874	2464	1797	3143	1431	756	275	54514	25397	17739
2000	14241	23810	6231	5754	1727	1247	2259	940	733	56941	42700	18891
2001	76905	11653	19209	4694	3556	1186	835	1656	1143	120837	43932	32280
2002	3697	62888	9478	14158	3340	2161	714	493	1926	98855	95158	32270
2003	1816	3023	51184	7562	9859	2389	1154	482	1625	79095	77279	74256

Table 19. Fishing mortality rate for haddock in unit areas 5Zjm from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2002. The rate for ages 4+ is weighted by population numbers and is also shown as exploitation rate (%).

Year	Age Group										4+ (%)
	1	2	3	4	5	6	7	8	9+	4+	
1969	0.000	0.112	0.445	0.407	0.504	0.428	0.349	0.737	0.470	0.422	31
1970	0.010	0.159	0.057	0.180	0.425	0.371	0.302	0.258	0.543	0.287	23
1971	0.000	0.678	0.956	0.367	0.188	1.164	1.131	0.332	0.397	0.375	29
1972	0.058	0.003	0.453	0.832	0.467	0.096	0.993	0.288	0.210	0.219	18
1973	0.106	0.621	0.022	1.143	1.738	0.413	0.054	0.641	0.112	0.322	25
1974	0.007	0.336	0.156	0.000	0.242	0.491	0.003	0.051	0.050	0.059	5
1975	0.002	0.121	0.405	0.188	0.025	0.460	0.336	0.172	0.021	0.108	9
1976	0.004	0.064	0.096	0.414	0.171	0.000	0.522	0.000	0.016	0.262	21
1977	0.000	0.222	0.035	0.141	0.261	0.339	0.000	1.007	0.017	0.180	15
1978	0.002	0.072	0.486	0.121	0.194	0.460	0.293	0.107	0.013	0.195	16
1979	0.000	0.005	0.062	0.385	0.419	0.363	0.704	0.249	0.022	0.379	29
1980	0.002	0.608	0.142	0.122	0.385	0.402	0.416	0.346	0.019	0.309	24
1981	0.000	0.147	0.486	0.241	0.304	0.348	0.465	0.178	0.012	0.295	23
1982	0.000	0.215	0.358	0.390	0.192	0.401	0.361	0.481	0.107	0.358	27
1983	0.000	0.121	0.302	0.320	0.407	0.304	0.185	0.343	0.065	0.341	26
1984	0.000	0.042	0.314	0.253	0.246	0.544	0.482	0.486	0.298	0.390	29
1985	0.002	0.216	0.302	0.387	0.216	0.175	0.345	0.246	0.128	0.247	20
1986	0.003	0.035	0.427	0.208	0.610	0.209	0.246	0.263	0.049	0.221	18
1987	0.000	0.228	0.150	0.490	0.177	0.527	0.214	0.229	0.104	0.365	28
1988	0.003	0.056	0.410	0.209	0.578	0.305	0.759	0.174	0.099	0.363	28
1989	0.000	0.111	0.114	0.238	0.359	0.436	0.130	1.606	0.047	0.247	20
1990	0.002	0.013	0.170	0.265	0.402	0.321	0.417	0.269	0.057	0.319	25
1991	0.005	0.295	0.207	0.456	0.307	0.381	0.675	0.825	0.092	0.423	32
1992	0.002	0.195	0.347	0.507	0.679	0.556	0.609	0.544	0.159	0.584	41
1993	0.002	0.048	0.492	0.591	0.770	0.723	0.428	0.667	0.171	0.593	41
1994	0.002	0.034	0.191	0.416	0.222	1.885	0.308	0.886	0.095	0.338	26
1995	0.003	0.008	0.093	0.153	0.252	0.147	0.506	0.197	0.047	0.153	13
1996	0.002	0.010	0.071	0.216	0.230	0.527	0.154	2.122	0.174	0.224	18
1997	0.003	0.023	0.030	0.107	0.182	0.158	0.195	0.092	0.114	0.136	12
1998	0.001	0.021	0.103	0.126	0.149	0.254	0.129	0.273	0.123	0.164	14
1999	0.001	0.006	0.114	0.155	0.165	0.130	0.220	0.154	0.104	0.157	13
2000	0.001	0.015	0.083	0.281	0.176	0.200	0.110	0.244	0.106	0.216	18
2001	0.001	0.007	0.105	0.140	0.298	0.307	0.328	0.164	0.189	0.218	18
2002	0.001	0.006	0.026	0.162	0.135	0.428	0.193	0.275	0.179	0.188	16

Table 20. Beginning of year biomass (tonnes in 000's) for haddock in unit areas SZjm from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2003.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
1969	88	97	4091	1283	1803	21079	8204	541	2788	39975	39886	39789
1970	385	324	129	3451	926	1049	13027	5111	1676	26079	25694	25371
1971	52	1397	411	161	3127	583	687	8505	4600	19523	19471	18074
1972	618	192	1055	208	121	2495	173	196	8409	13466	12848	12656
1973	1268	2136	285	884	98	73	2150	56	5722	12672	11404	9268
1974	384	4179	1708	367	306	17	46	1799	4217	13021	12637	8458
1975	370	1398	4441	1924	398	231	10	40	4928	13740	13370	11971
1976	6199	1355	1844	3900	1729	374	138	6	3983	19527	13328	11973
1977	678	22618	1890	2206	2796	1404	355	73	3214	35234	34556	11938
1978	483	2485	26962	2404	2077	2074	949	313	2613	40361	39878	37393
1979	5968	1768	3441	21839	2310	1648	1242	625	2383	41224	35257	33488
1980	763	21869	2617	4258	16115	1464	1087	543	2377	51092	50329	28461
1981	588	2790	17719	2990	4086	10567	929	633	2278	42580	41992	39202
1982	197	2155	3583	14346	2549	2905	7076	515	2353	35678	35481	33326
1983	291	720	2586	3300	10534	2026	1844	4354	2038	27694	27403	26682
1984	1710	1065	949	2518	2600	6759	1418	1353	4540	22912	21202	20136
1985	178	6268	1520	913	2120	1959	3720	773	3561	21013	20835	14567
1986	1781	572	7829	1421	1028	1999	2065	2682	3581	22957	21176	20604
1987	191	5393	717	7179	1316	383	1468	1158	4399	22203	22012	16619
1988	1456	484	6547	1267	3911	861	198	1006	4389	20118	18662	18178
1989	49	5795	524	5324	935	2500	584	80	3308	19099	19050	13255
1990	351	338	8280	696	4594	555	1313	548	2872	19547	19196	18858
1991	214	1320	416	9353	627	3290	335	882	2614	19051	18836	17517
1992	932	880	1312	368	6675	482	2048	151	2306	15154	14222	13342
1993	1265	2996	1207	1226	218	3111	245	922	1639	12828	11563	8568
1994	1278	3976	5084	798	594	139	1672	150	1500	15192	13914	9938
1995	408	4828	6459	5113	591	494	19	954	1213	20079	19672	14843
1996	707	1911	7303	6606	4461	432	414	10	1837	23683	22976	21065
1997	1589	2112	2448	7302	5492	3269	201	258	1114	23784	22195	20083
1998	1005	5255	3453	2891	6993	4403	2741	196	1151	28088	27083	21827
1999	3775	3628	7171	3177	2262	5875	3049	2056	823	31815	28040	24413
2000	1648	12937	5912	8506	3230	2231	5192	2358	2127	44141	42492	29556
2001	7180	6101	19311	6436	6391	2568	1880	4295	3347	57509	50329	44228
2002	354	20852	7374	16108	4989	4246	1555	1087	5214	61779	61425	40573
2003	146	1117	43305	8037	14563	3930	2548	1076	4043	78763	78617	77501

Table 21. Risk projection input for haddock in unit areas 5Zjm. A catch of 8000t in 2003, 10 million recruits for the 2003 and 2004 year-classes and $M = 0.2$ were assumed for the forecasts.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
<i>Population Numbers (000s)</i>									
2003.25	2109	3087	51176	7517	9635	2297	1129	480	1576
<i>Partial Recruitment to the Fishery¹</i>									
2003.25	0	0.09	0.5	1	1	1	1	1	1
2004	0	0.09	0.5	1	1	1	1	1	1
<i>Weight at beginning of year for population (kg)²</i>									
2003.25	0.08	0.37	0.85	1.06	1.48	1.64	2.21	2.23	2.49
2004	0.08	0.37	0.85	1.06	1.48	1.64	2.21	2.23	2.49
2005	0.08	0.37	0.85	1.06	1.48	1.64	2.21	2.23	2.49
<i>Weight at age for catch (kg)³</i>									
2003.25	0.54	1.09	1.5	1.81	2.03	2.26	2.55	2.78	3.67
2004	0.54	1.09	1.5	1.81	2.03	2.26	2.55	2.78	3.67

¹Average of 1997 – 2001.

²Equal to 2003 from DFO survey.

³Average of 1998 – 2002 from fishery.

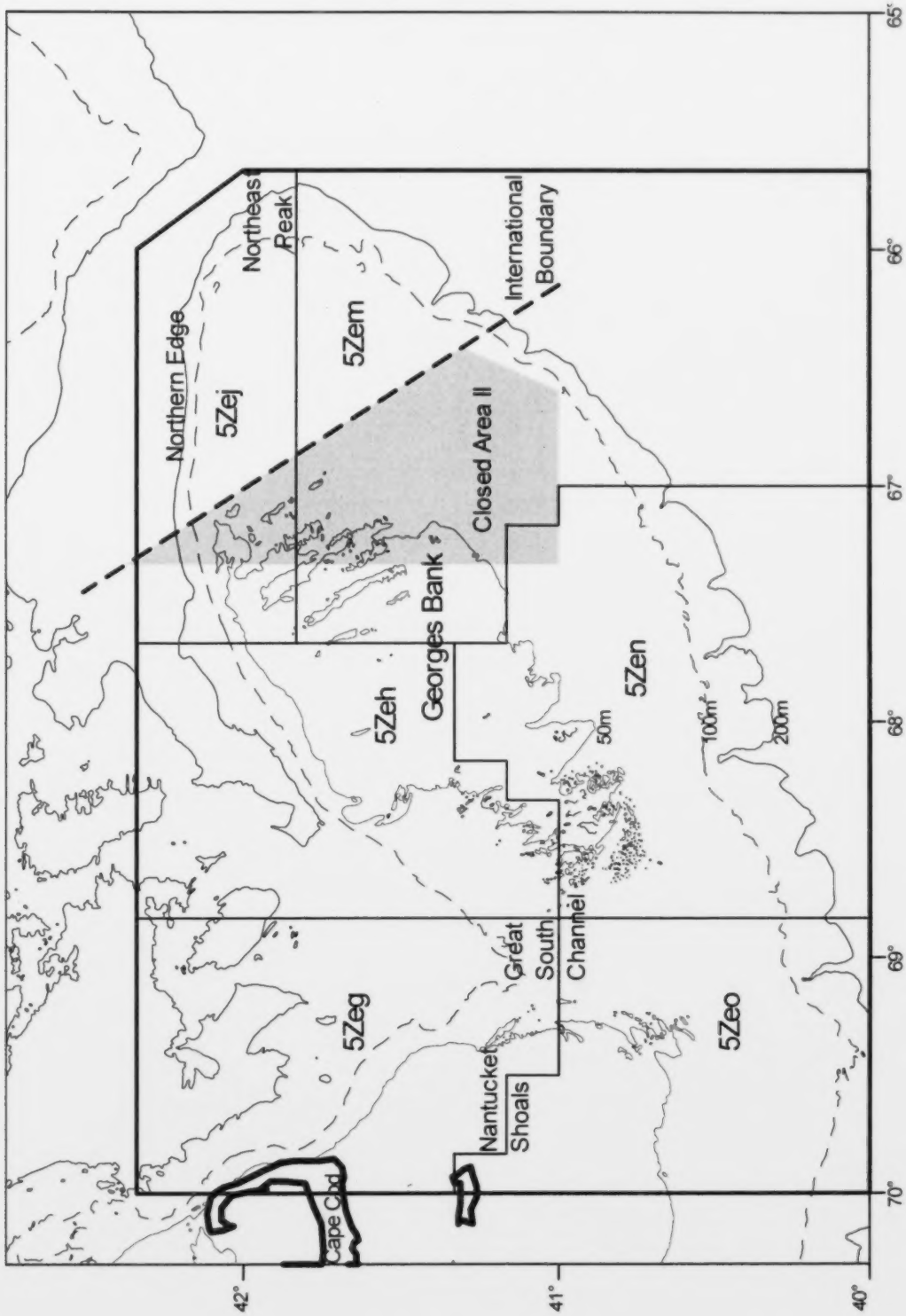


Figure 1. Fisheries statistical unit areas in NAFO Subdivision 5Ze.

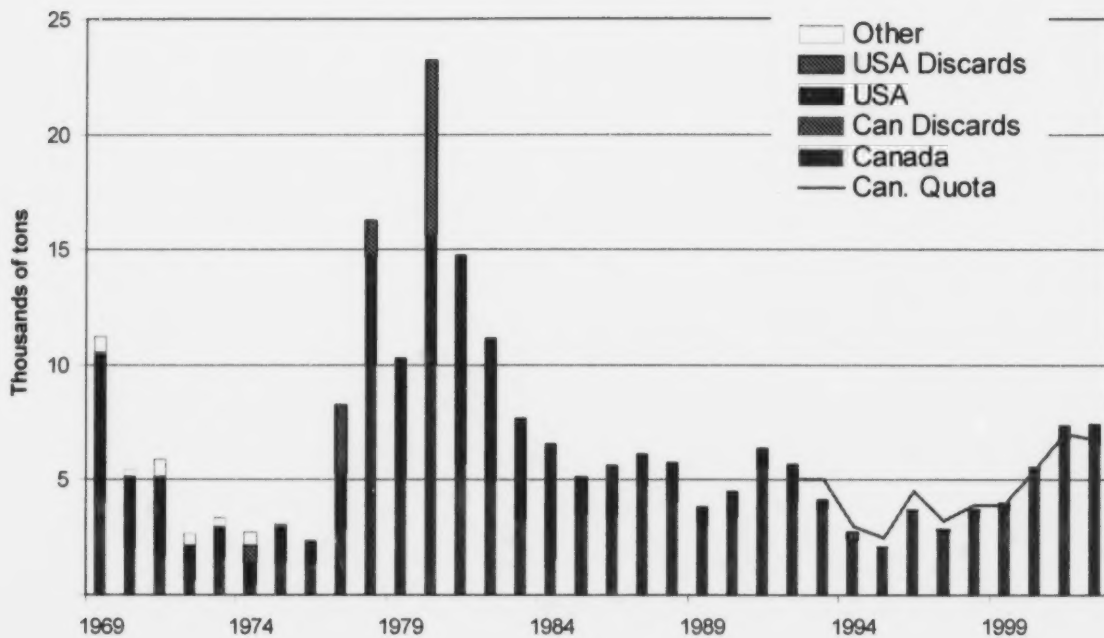


Figure 2. Nominal catch of haddock in unit areas 5Zjm.

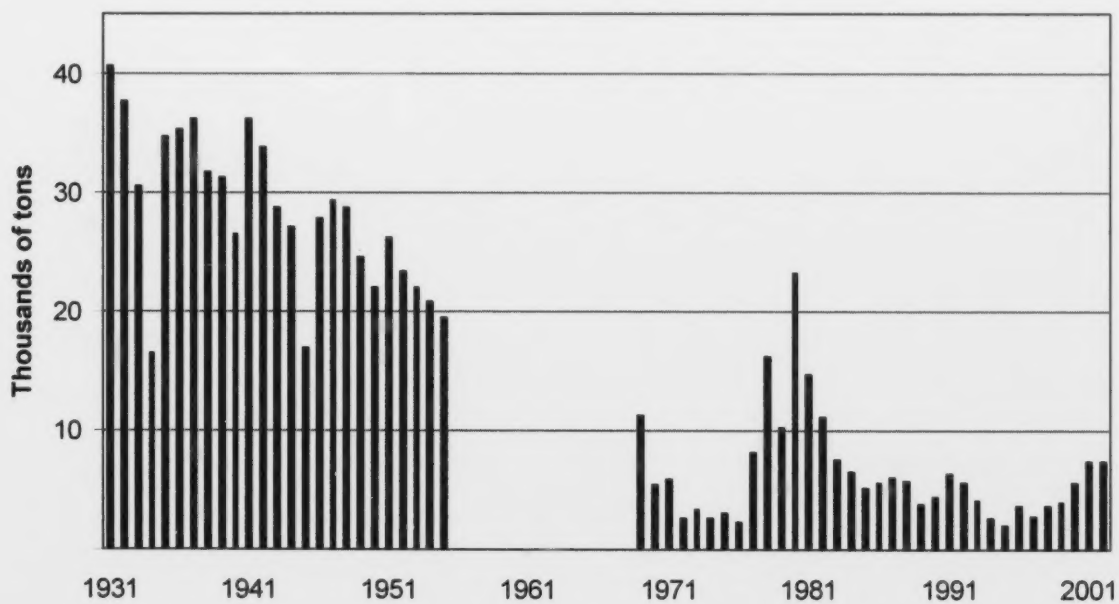


Figure 3. Historical catch of haddock in 5Zjm compared to recent catches.

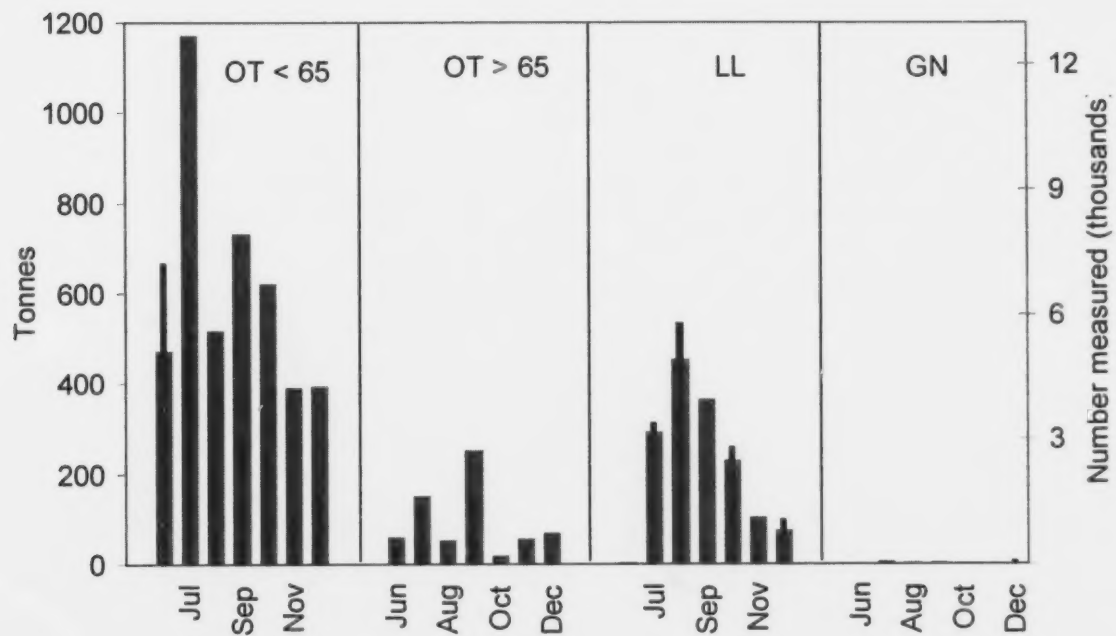


Figure 4. Haddock catches in 5Zjm by month and gear for the Canadian commercial fishery in 2002 (wide gray bars) with sampling levels (narrow black bars).

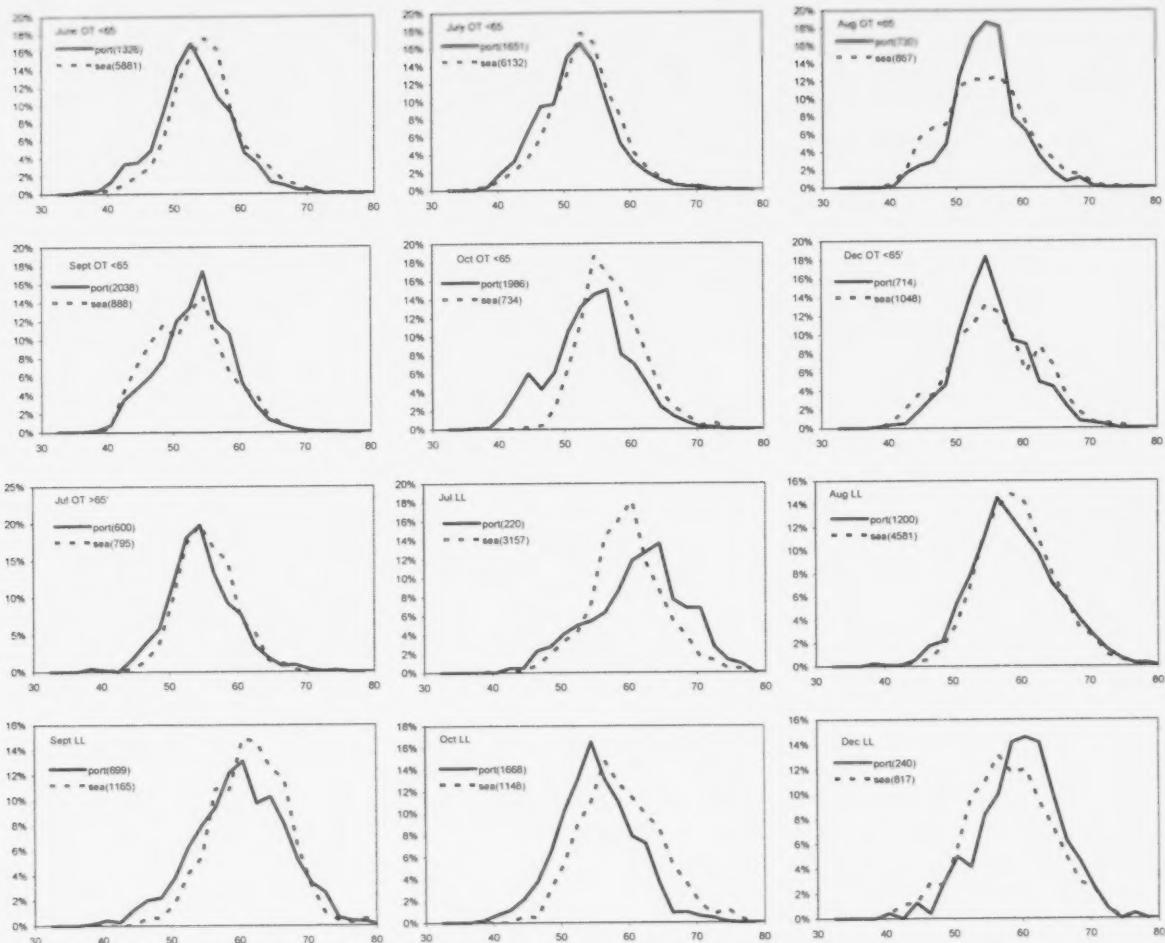


Figure 5. Comparison of length frequencies obtained at port and at sea from the Georges Bank commercial fishery in 2002. The number of fish measured is shown in brackets.

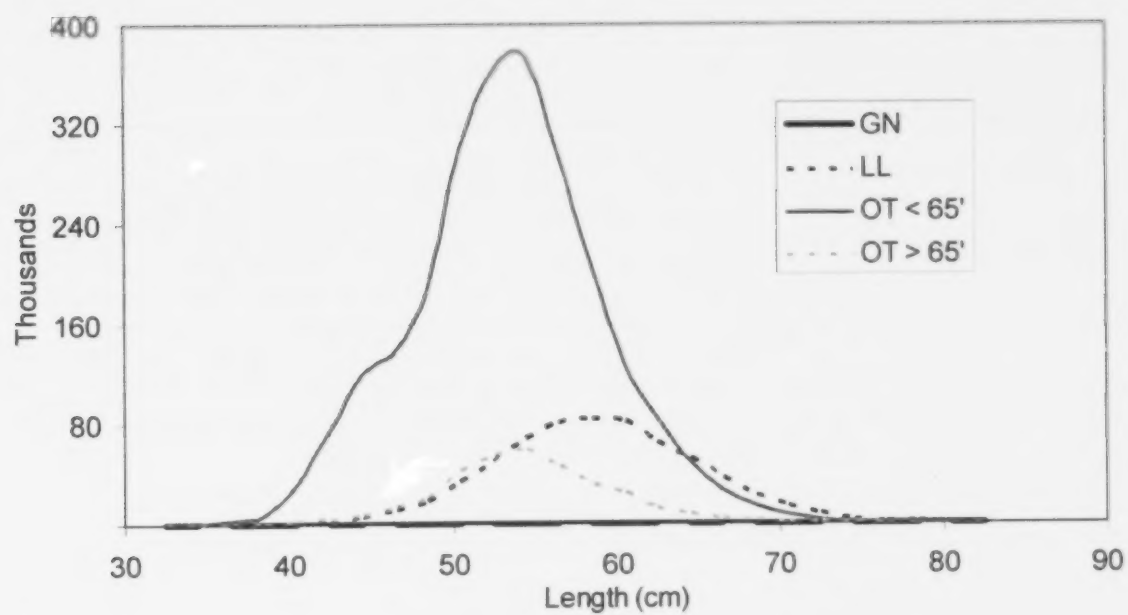


Figure 6. Catch at length by the principal Canadian 5Zjm commercial haddock fisheries in 2002.

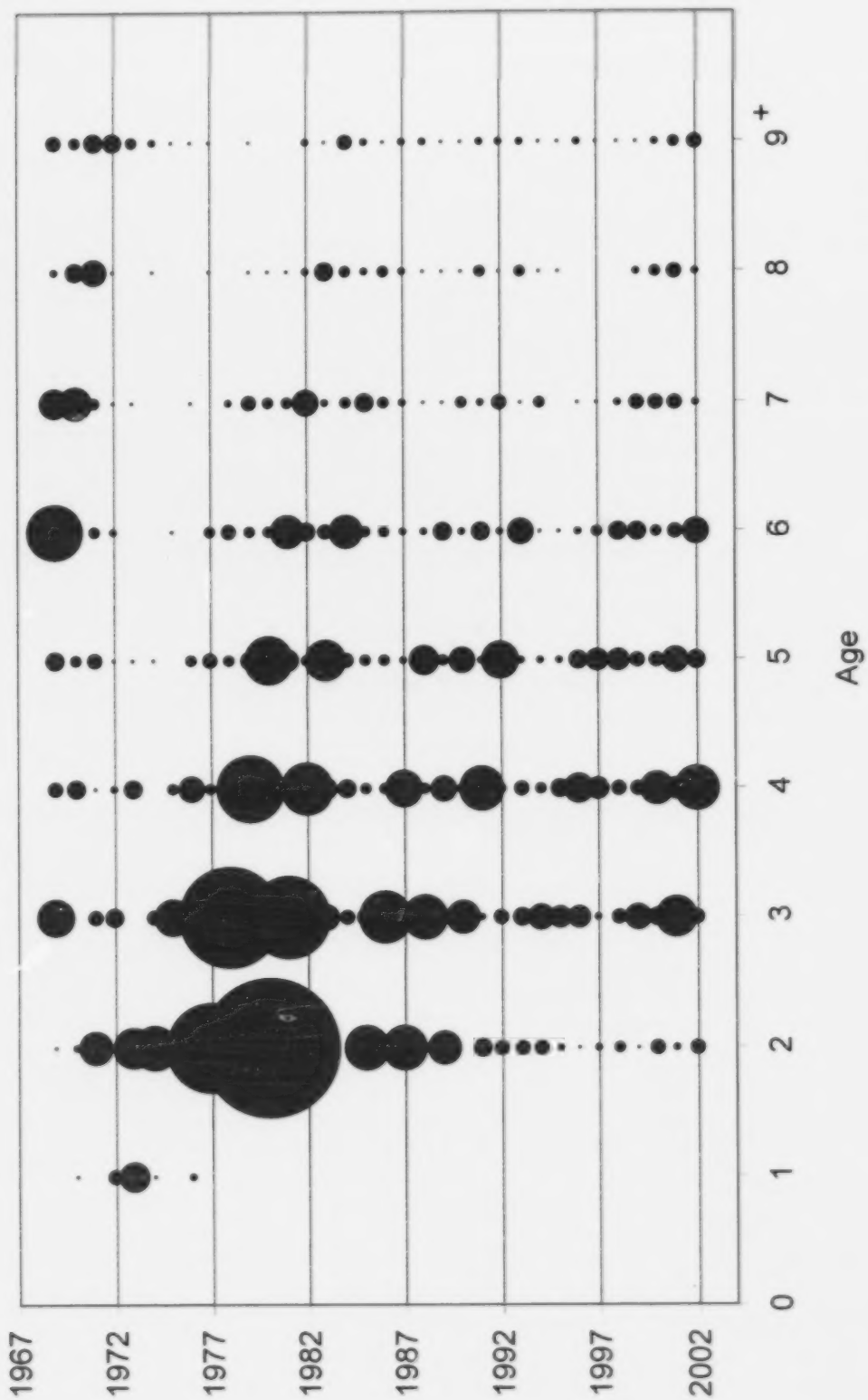


Figure 7. Total commercial catch at age (numbers) of haddock from unit areas 5Zjm. The bubble area is proportional to magnitude (see Table 9).

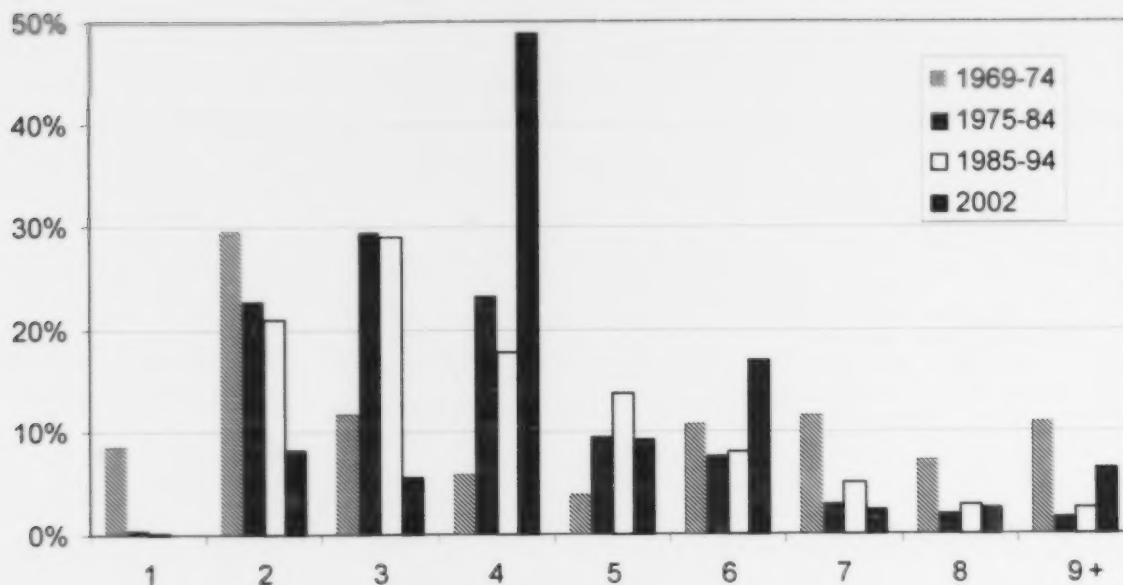


Figure 8. Age composition of the haddock catch for the Canadian 5Zjm commercial fishery in 2002 compared to the average age composition for the total catch of all fisheries during three earlier periods.

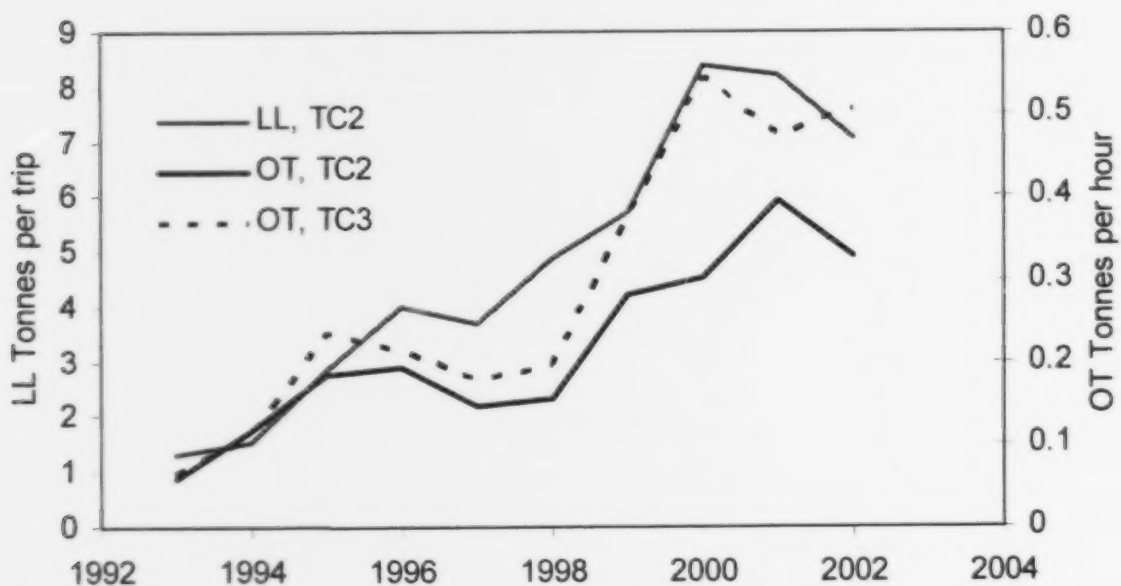


Figure 9. Catch rates for haddock from the Canadian commercial fishery in 5Zjm. (LL = longline, OT = otter trawl, TC = tonnage class).

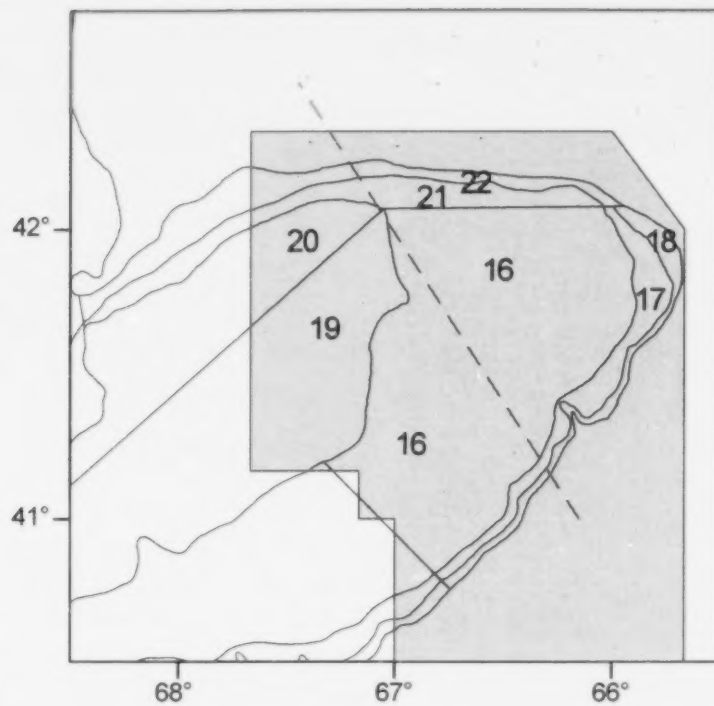


Figure 10. Stratification scheme used for NMFS surveys. The 5Zjm management area is indicated by shading.

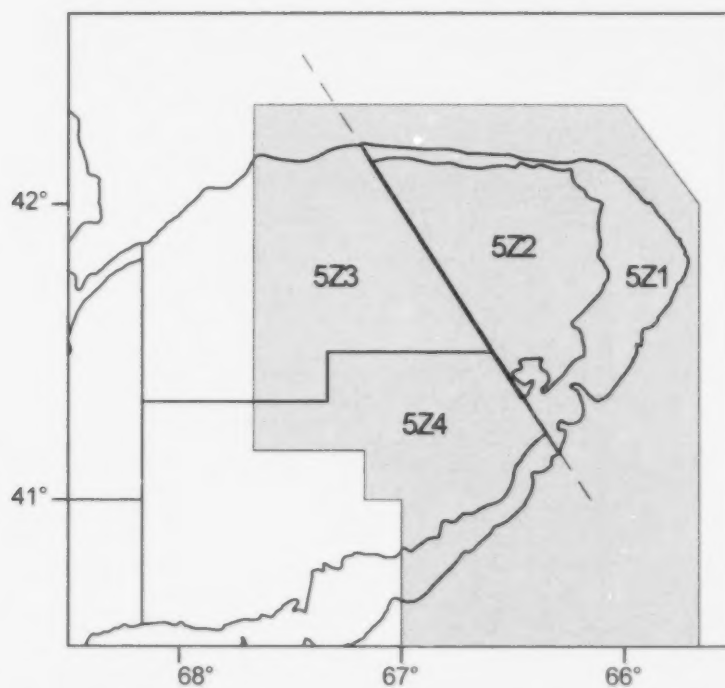


Figure 11. Stratification scheme used for the DFO survey. The 5Zjm management area is indicated by shading.

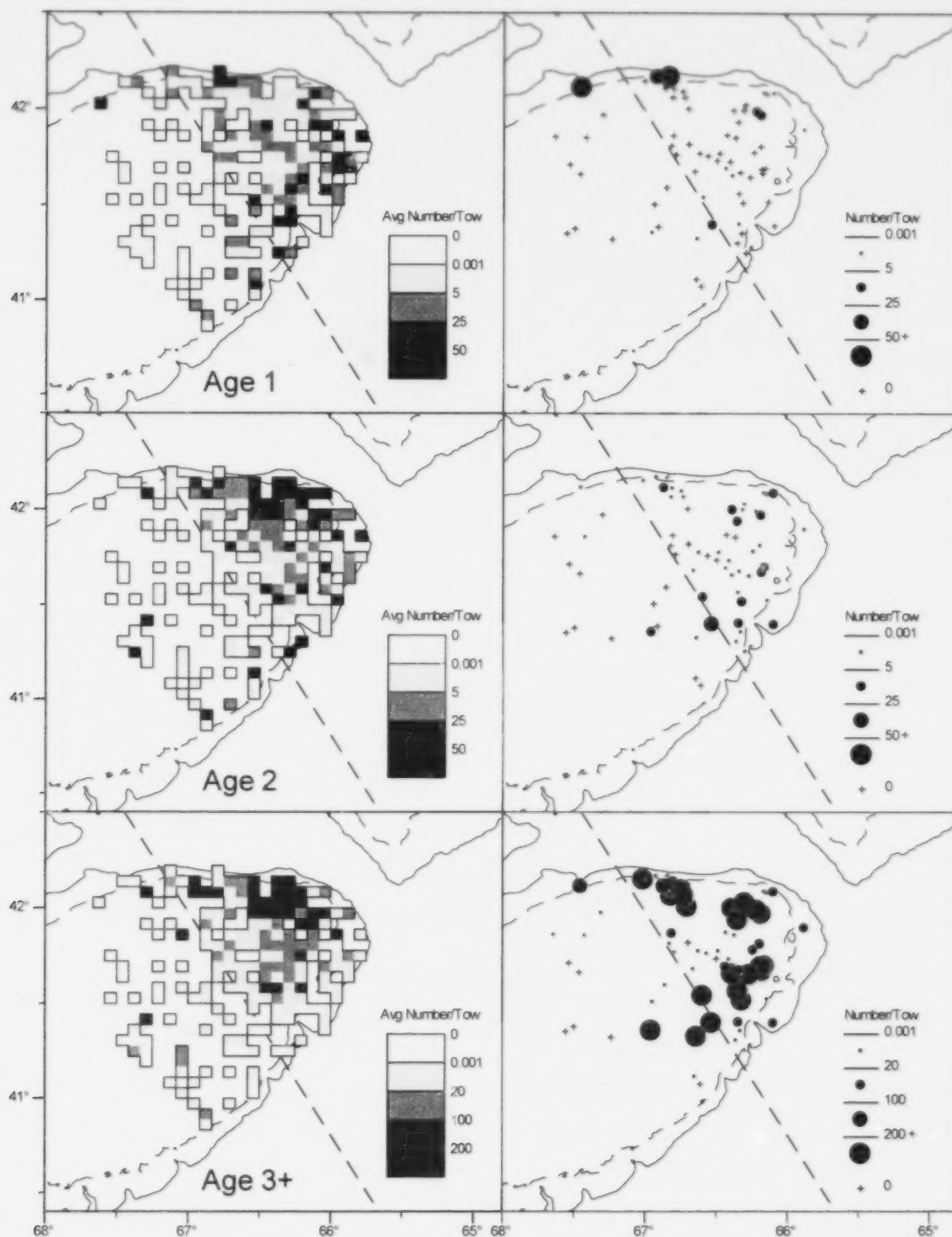


Figure 12. Distribution of 5Zjm haddock abundance (number/tow) as observed from the DFO survey. The squares (left panels) are shaded relative to the average catch for 1998 to 2002. The expanding symbols (right panels) represent the 2003 survey catches.

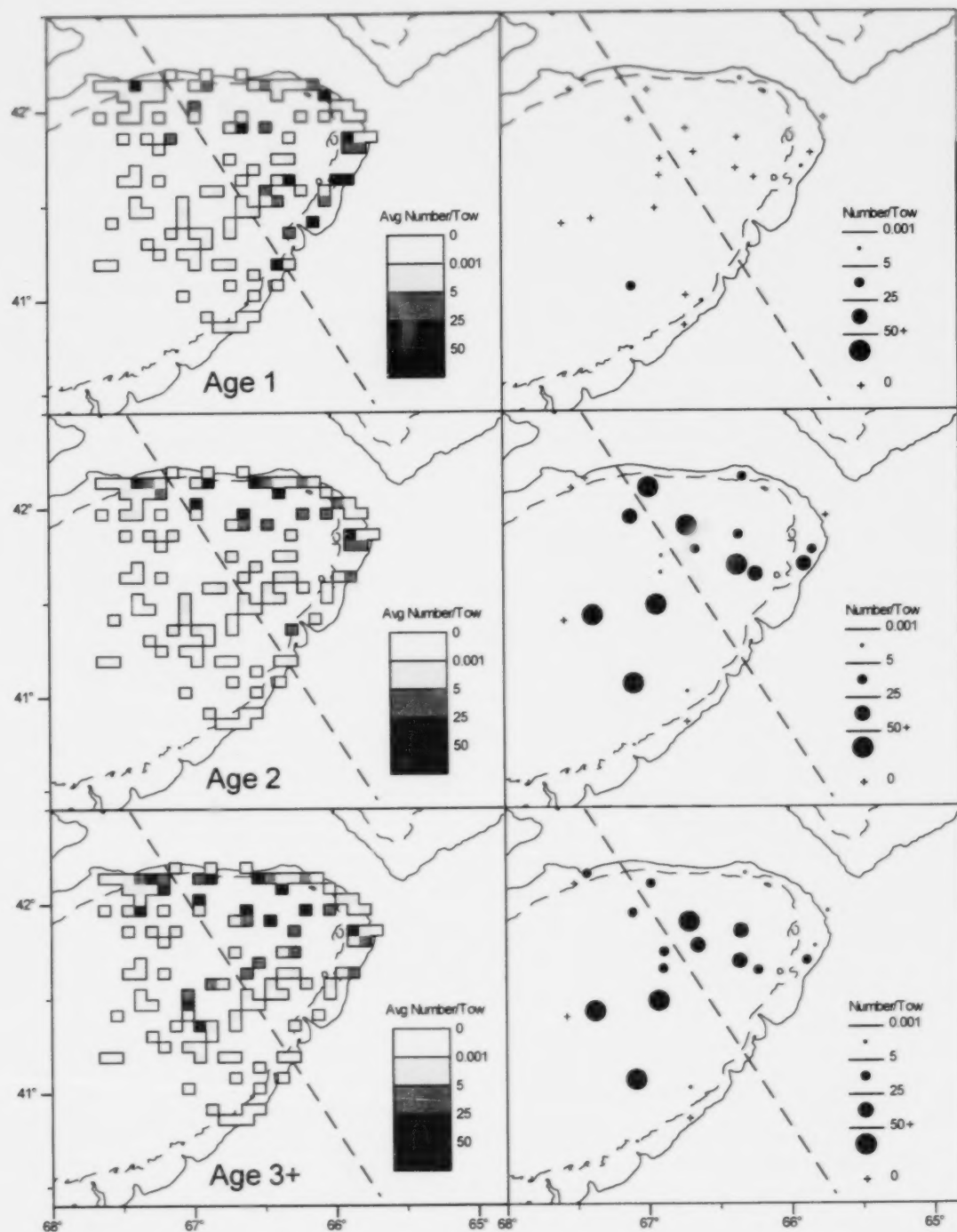


Figure 13. Distribution of 5Zjm haddock abundance (number/tow) as observed from the NMFS spring survey. The squares (left panels) are shaded relative to the average catch for 1997 to 2001. The expanding symbols (right panels) represent the 2002 survey catches.

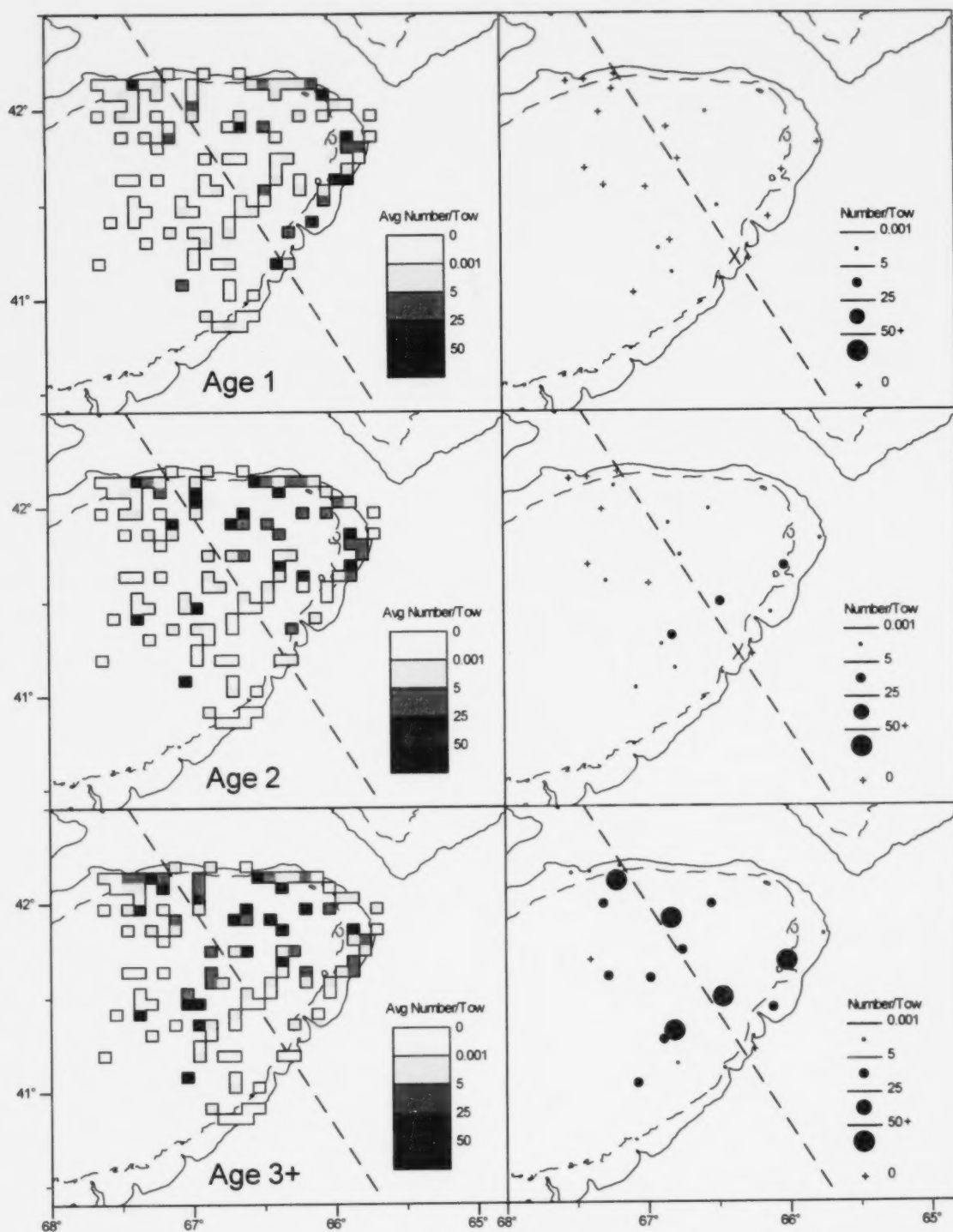


Figure 14. Distribution of 5Zjm haddock abundance (number/tow) as observed from the NMFS **spring** survey. The squares (left panels) are shaded relative to the average catch for 1998 to 2002. The expanding symbols (right panels) represent the **2003** survey catches.

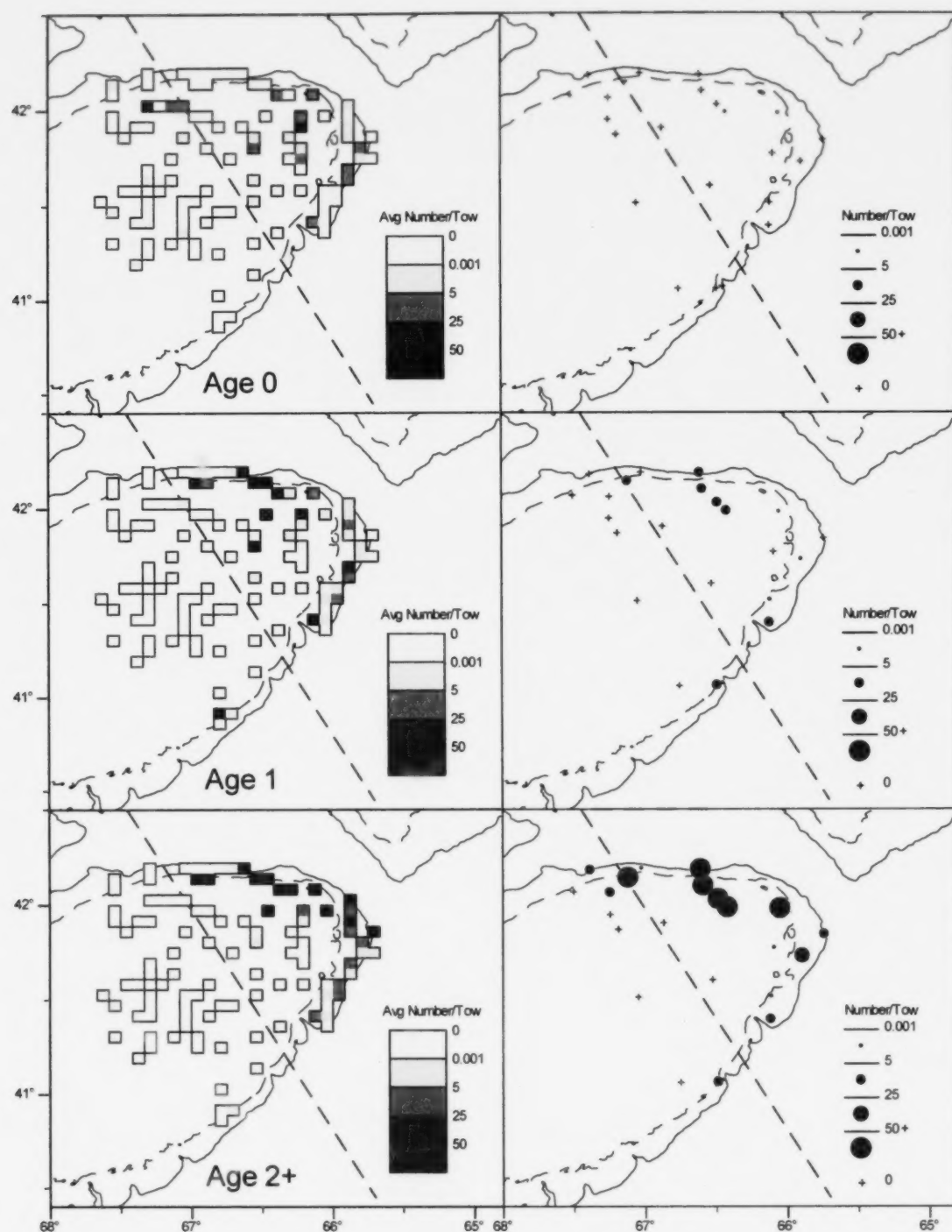


Figure 15. Distribution of 5Zjm haddock abundance (number/tow) as observed from the NMFS fall survey. The squares (left panels) are shaded relative to the average catch for 1997 to 2001. The expanding symbols (right panels) represent the 2002 survey catches.

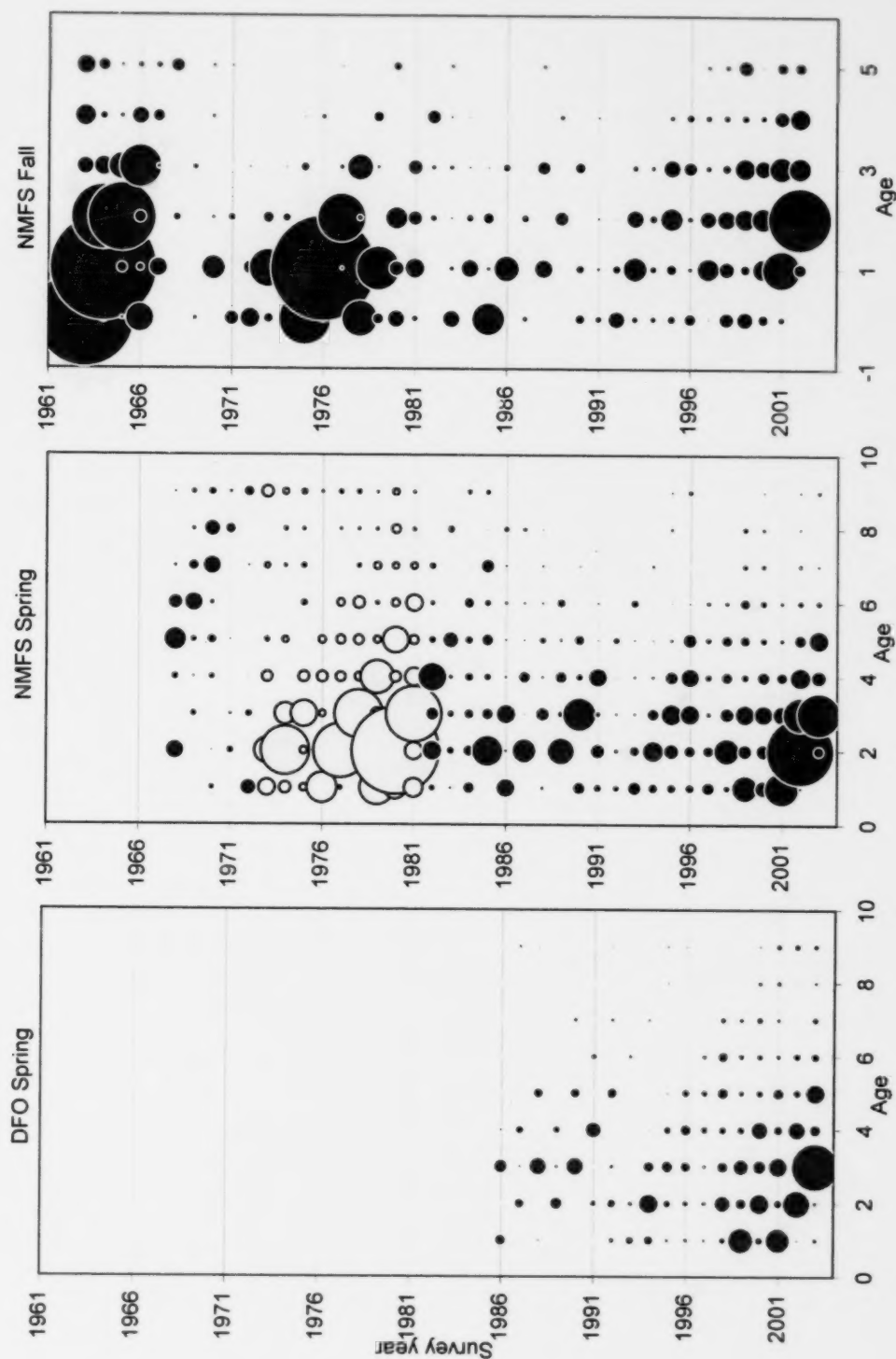


Figure 16. Estimated abundance at age (numbers in 000's) of haddock for the DFO and NMFS spring surveys and the NMFS fall survey. Bubble area is proportional to magnitude (see Tables 12-14). Conversion factors to adjust for changes in door type and survey vessel were applied to the NMFS surveys. From 1973-81 (pale circles), a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years. Symbol size has not been adjusted between surveys for the catchability of the survey.

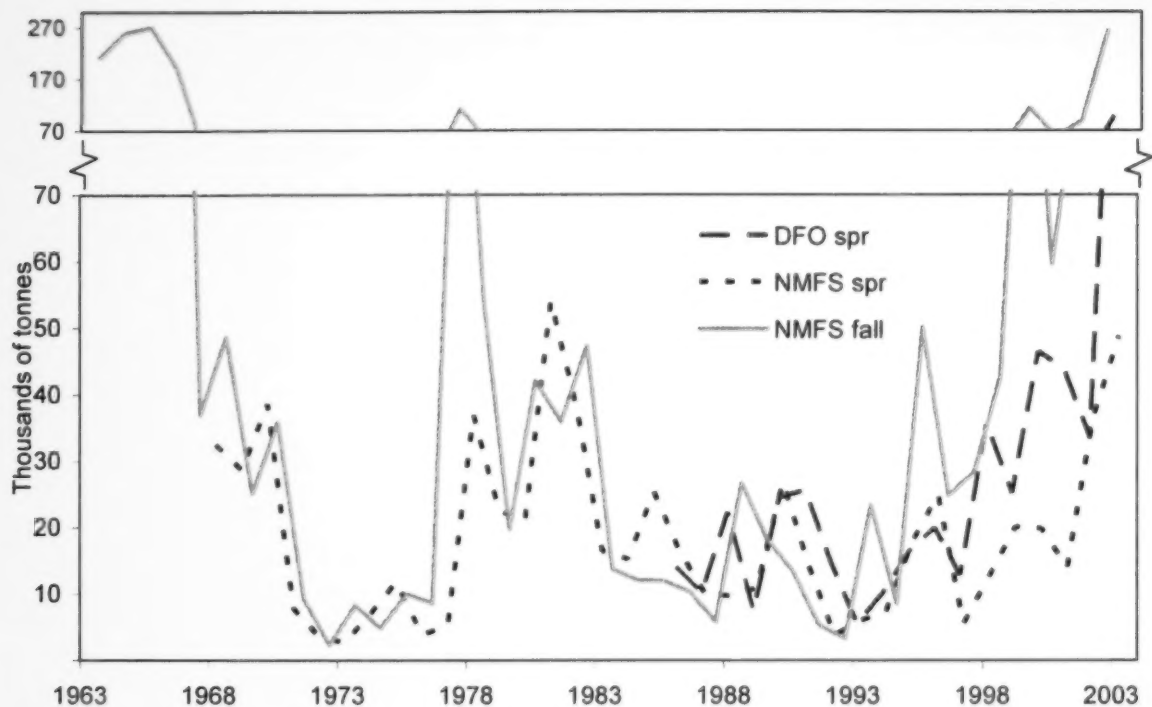


Figure 17. Biomass from NMFS fall (ages 2-8), NMFS spring (ages 3-8) and DFO (ages 3-8) research surveys (scaled by calibration constants, Table 16) for haddock in unit areas 5Zjm..

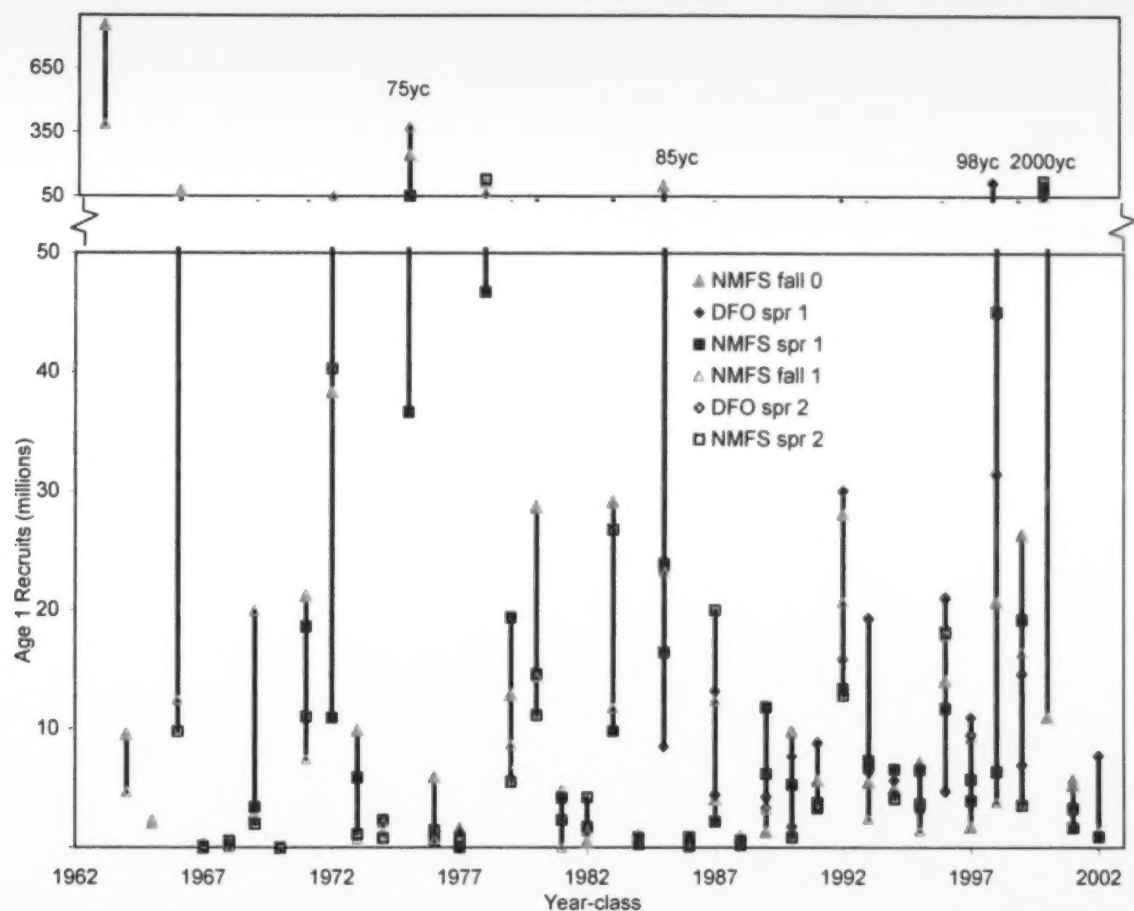


Figure 18. Year-class abundance for ages 0 and 1 from the NMFS fall and ages 1 and 2 from the NMFS and DFO spring research surveys (scaled by calibration constants, Table 16) for haddock in unit areas 5Zjm.

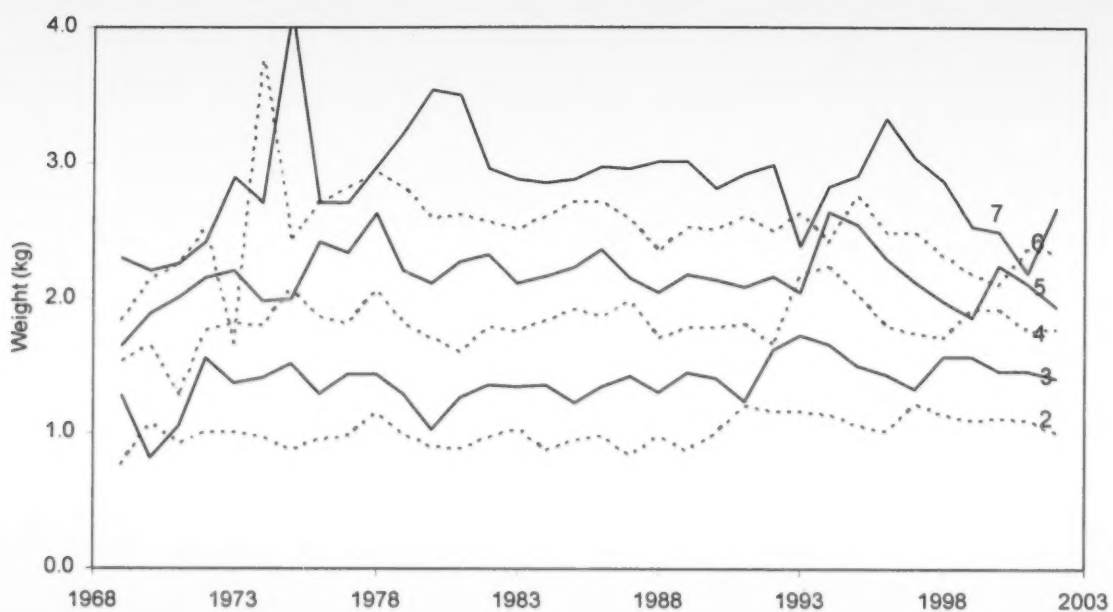


Figure 19. Weight at age for haddock in unit areas 5Zjm derived from the commercial fisheries.



Figure 20. Weight at age for haddock in unit areas 5Zjm derived from the DFO spring surveys.

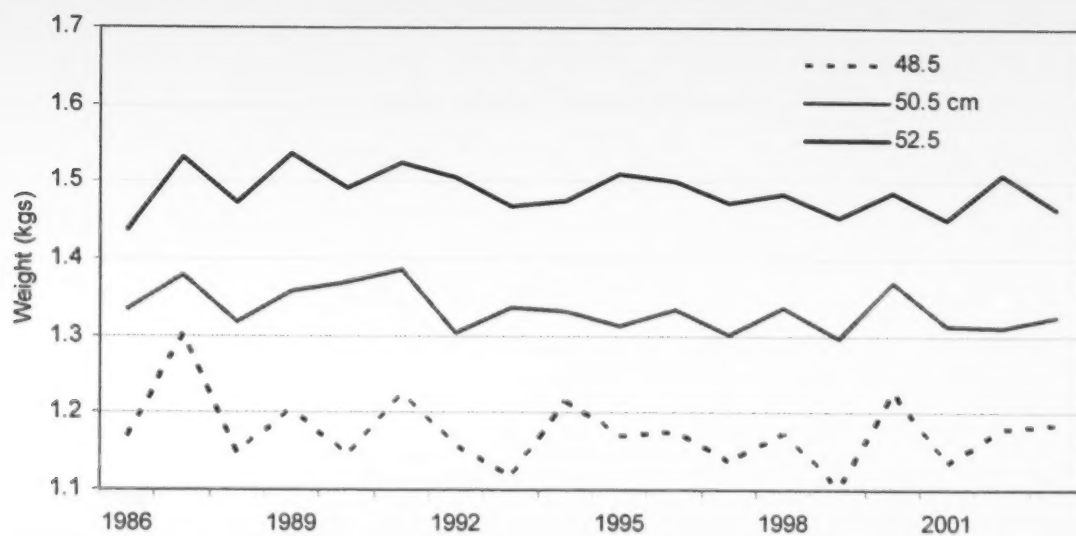


Figure 21. Weights at lengths for haddock in 5Zjm for 3 adjacent 2cm length groupings indicate that there are no alarming trends in condition.

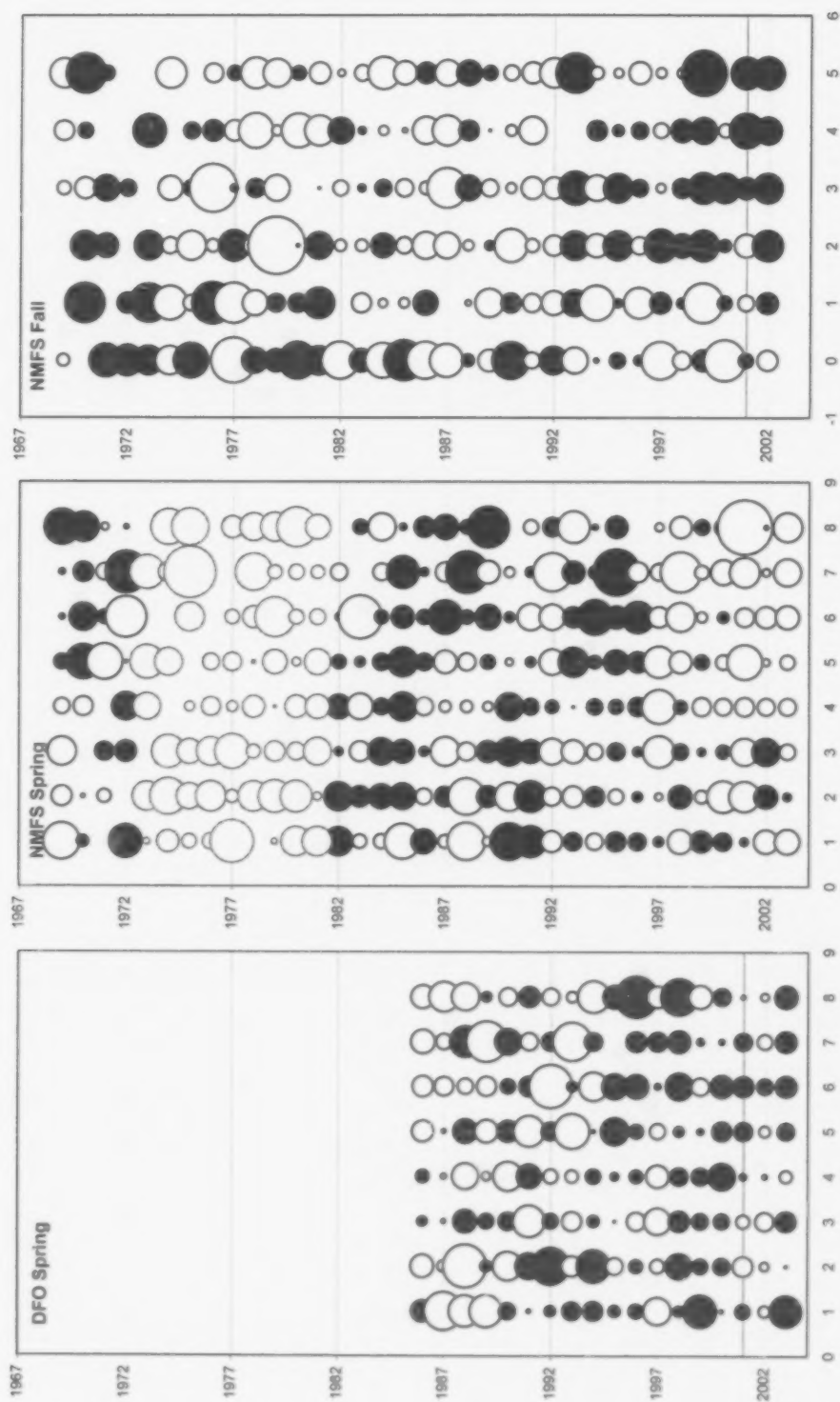


Figure 22. Residuals by year and age group for each research survey index. Solid symbols indicate positive values, open symbols indicate negative values. Bubble area is proportional to magnitude. From 1973-81 (pale circles), a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years.

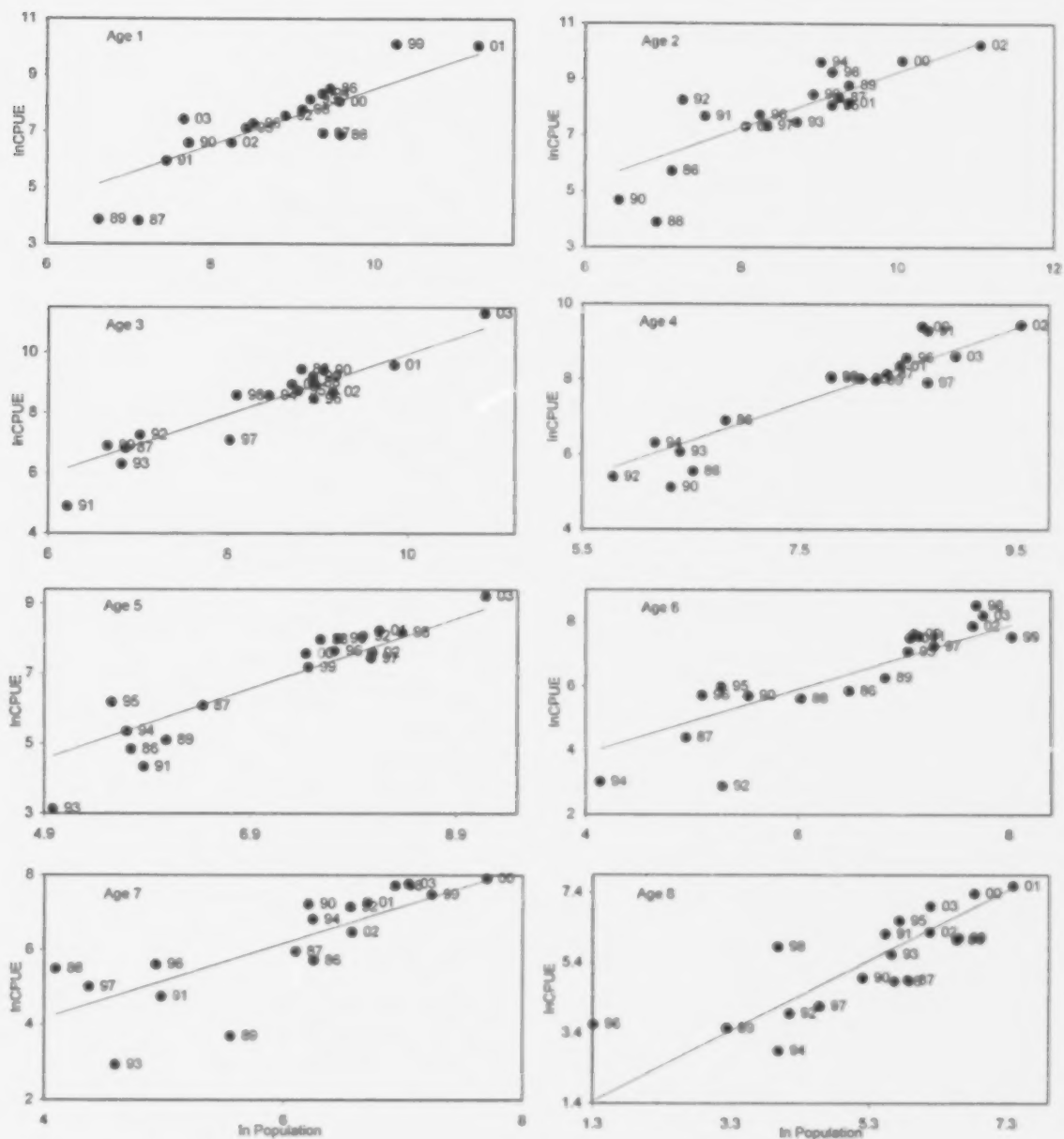


Figure 23. Age by age plots of the observed and predicted $\ln$ abundance index versus $\ln$ population numbers for haddock in unit areas 52j and 52m from the DFO survey.

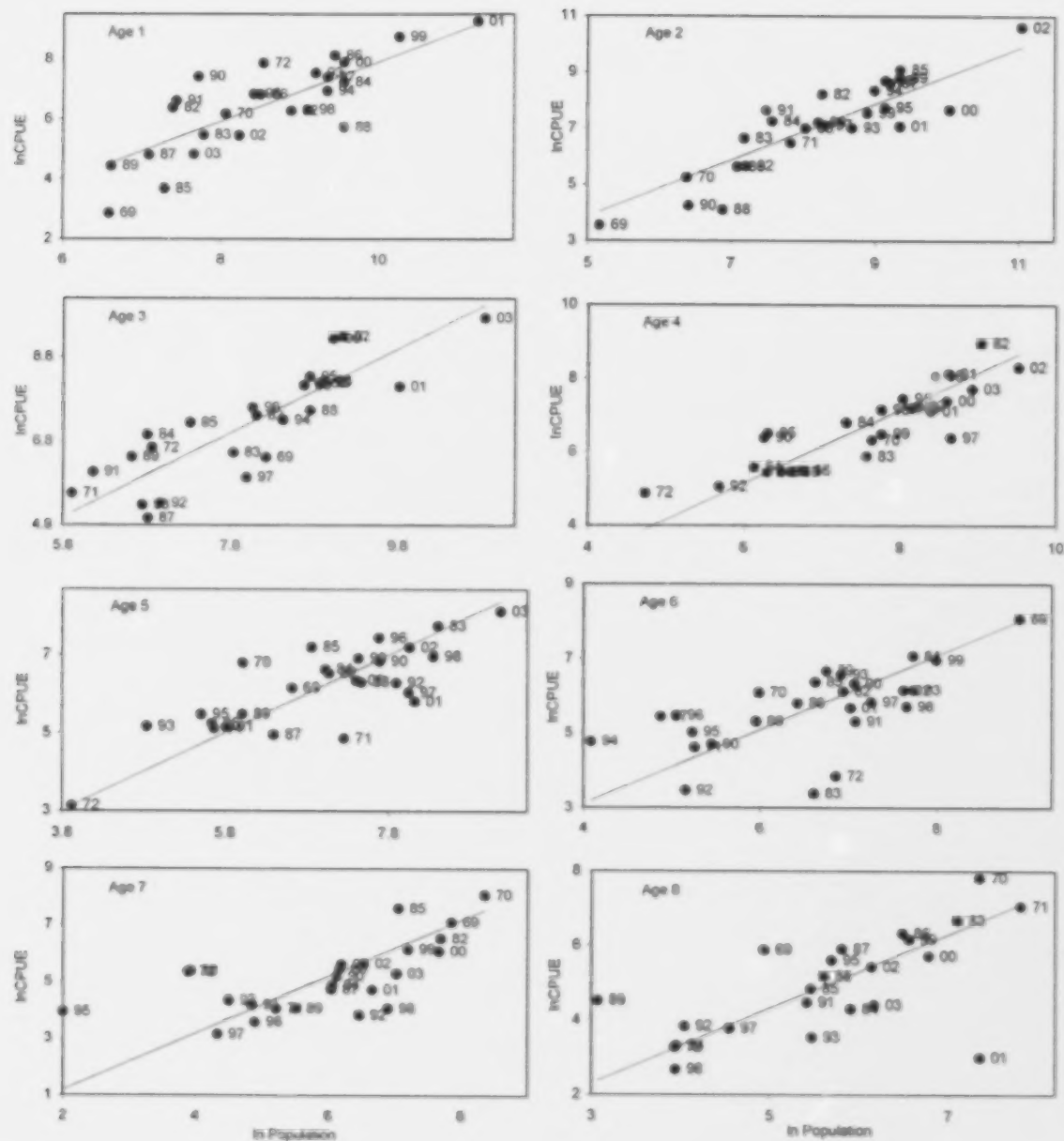


Figure 24. Age by age plots of the observed and predicted $\ln$ abundance index versus $\ln$ population numbers for haddock in unit areas 5Zj and 5Zm from the NMFS spring survey with a Yankee 36 net.

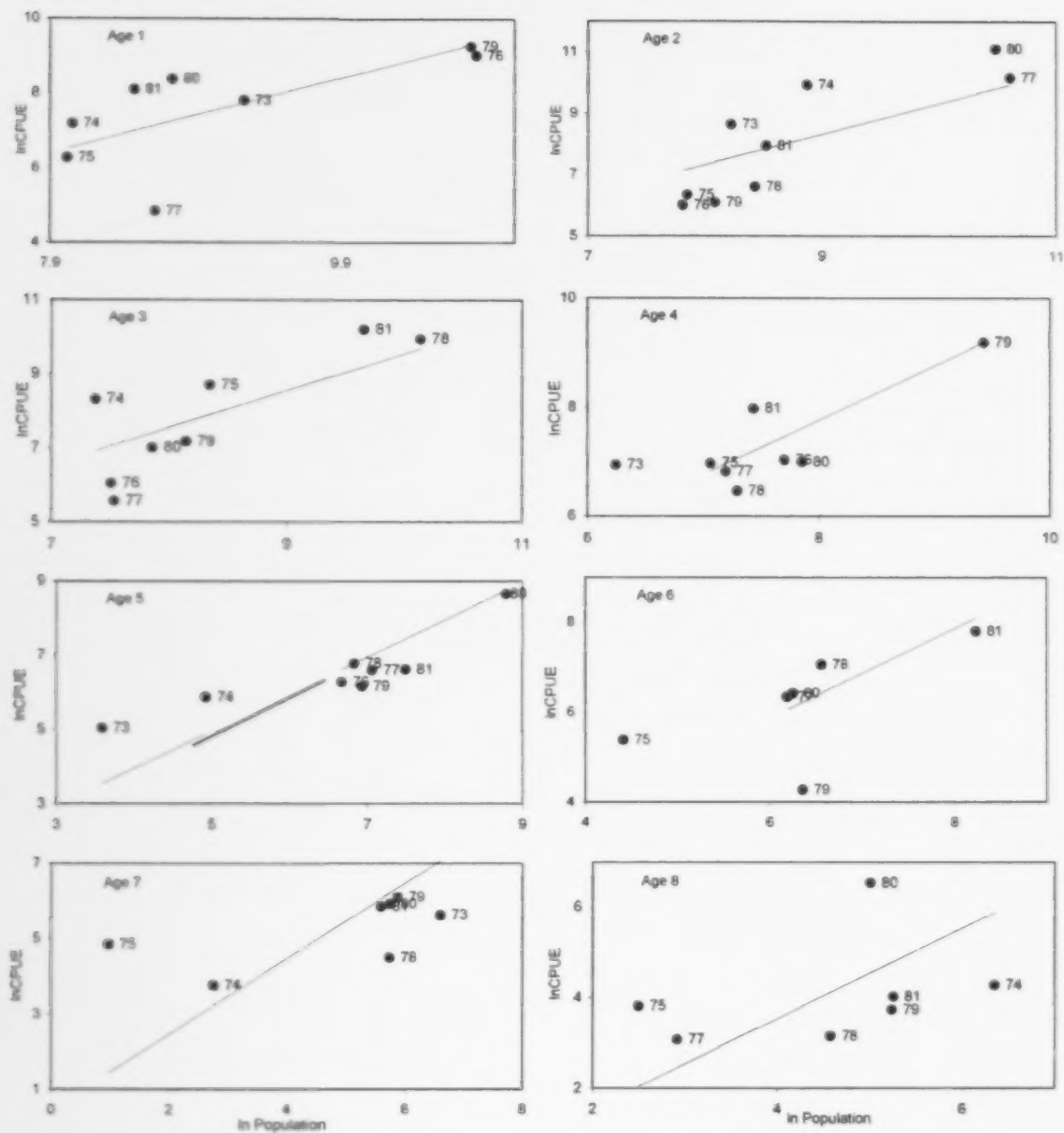


Figure 25. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for haddock in unit areas 5Zj and 5Zm from the NMFS spring survey with a Yankee 41 net.

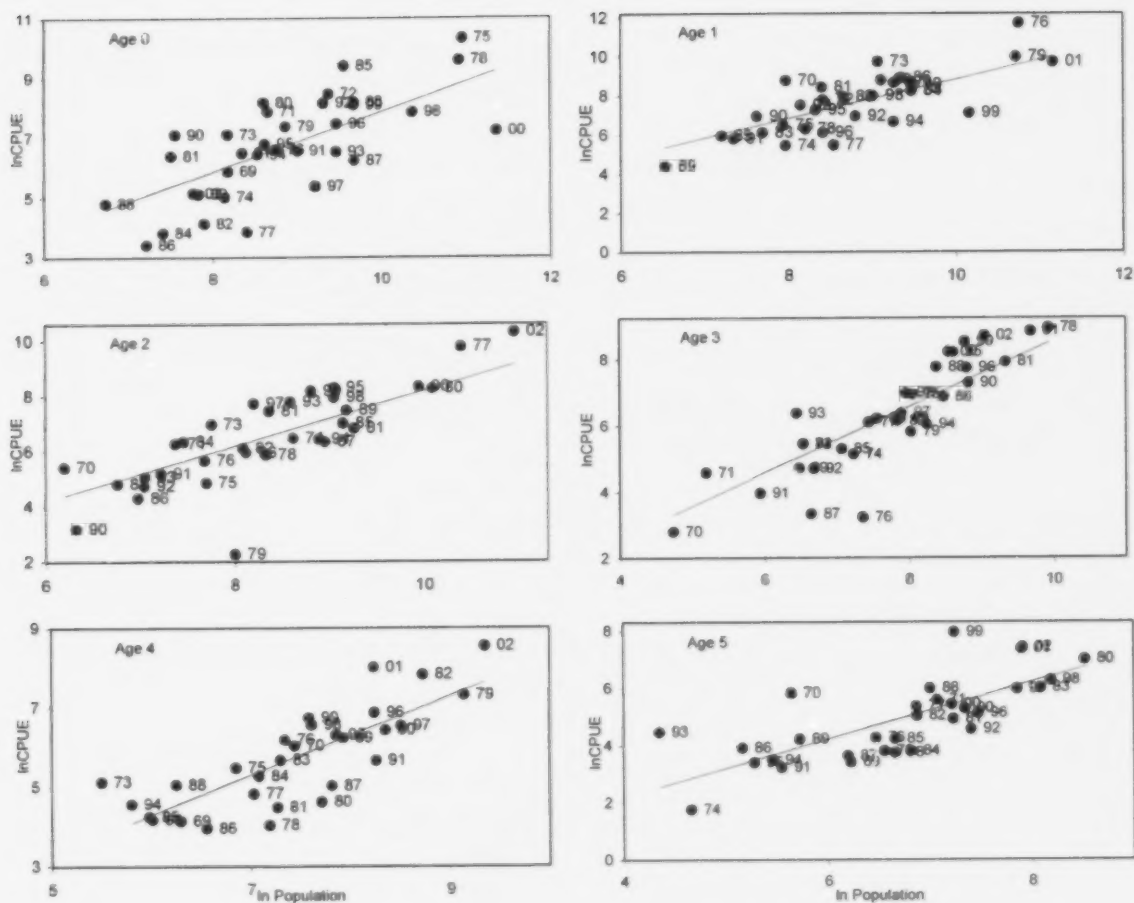


Figure 26. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for haddock in unit areas 5Zj and 5Zm from the NMFS fall survey.

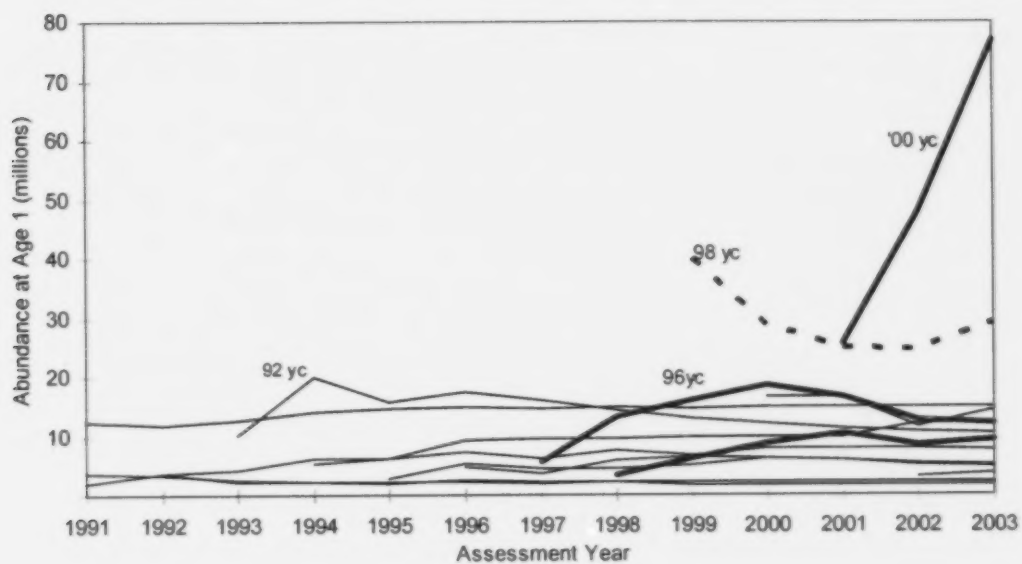


Figure 27. Successive estimates of 5Zjm haddock year-class abundance as additional years of data were included in the assessment did not display any persistent trends.

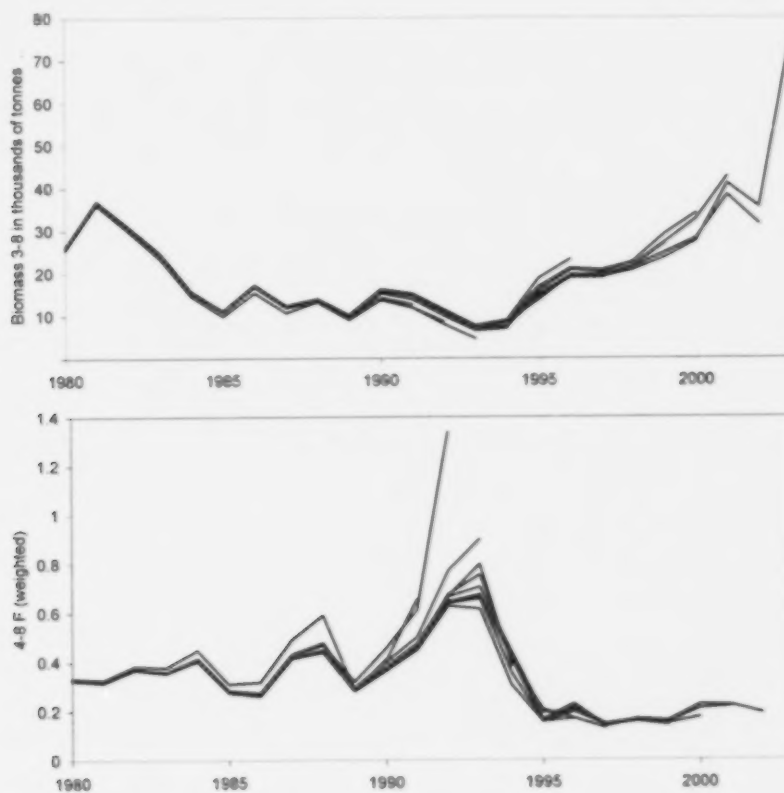


Figure 28. Retrospective estimates from VPA of 5Zjm haddock biomass and fishing mortality did not display any persistent trends for over or under estimation as successive years of data were excluded in the assessment.

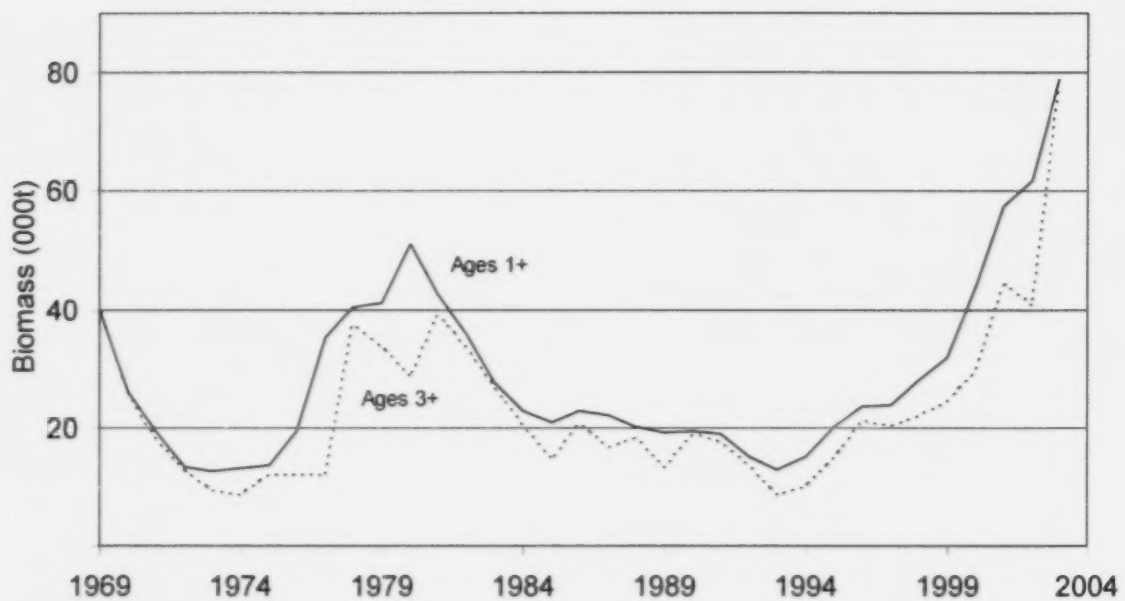


Figure 29. Beginning of year total (1+) and adult (3+) biomass for haddock in unit areas 5Zjm.

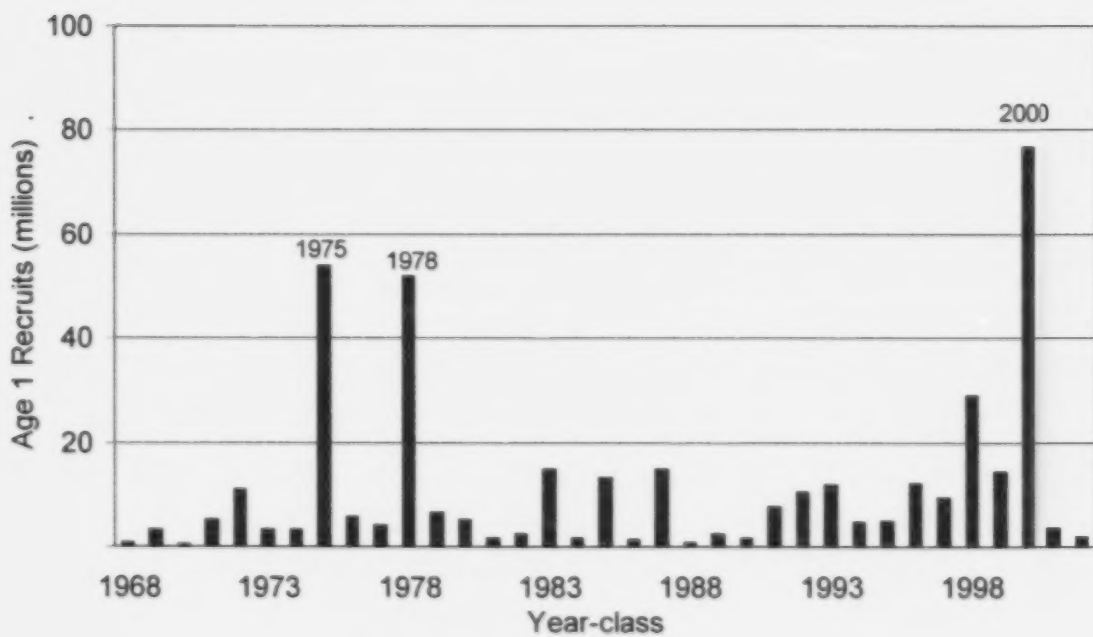


Figure 30. Number of age 1 recruits for haddock in unit areas 5Zjm.

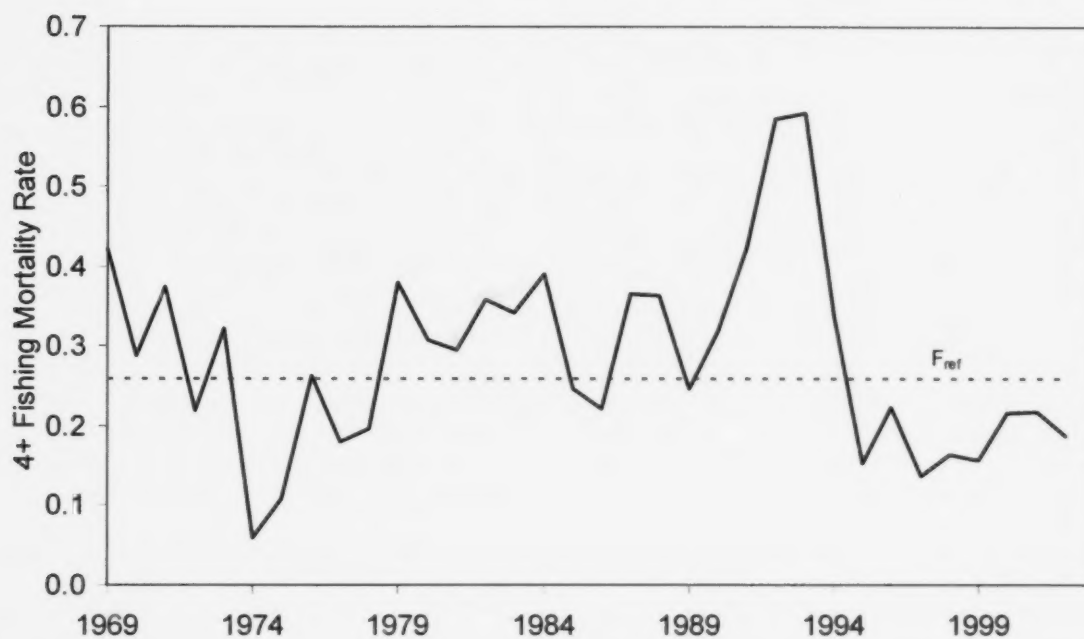


Figure 31. Fishing mortality rate for haddock ages 4+ in unit areas 5Zjm and the fishing mortality threshold reference established at $F_{ref} = 0.26$.

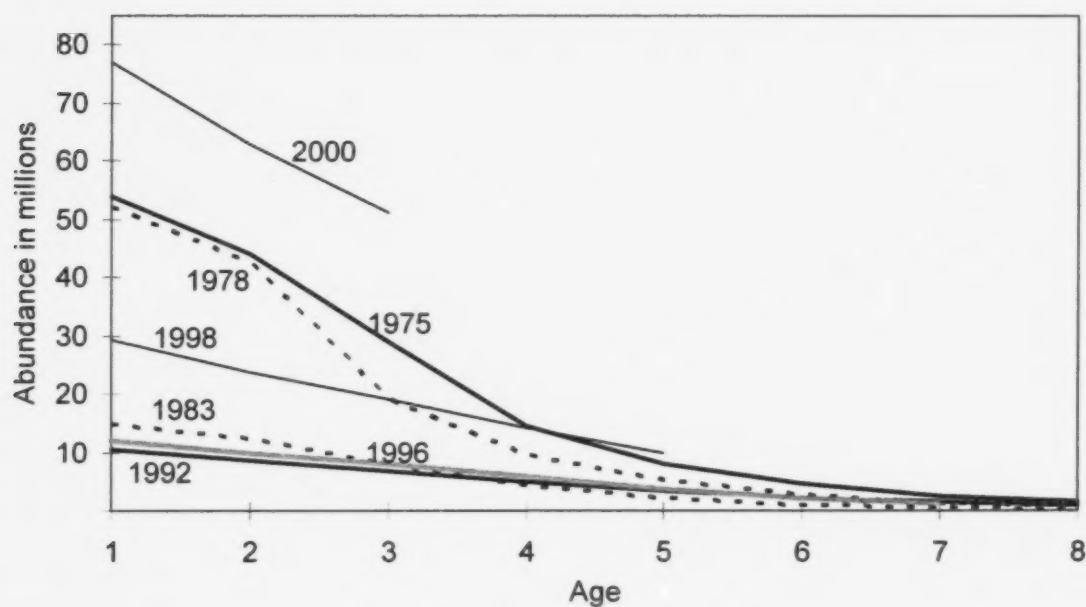


Figure 32. Decay of selected year-classes of the 5Zjm haddock population.

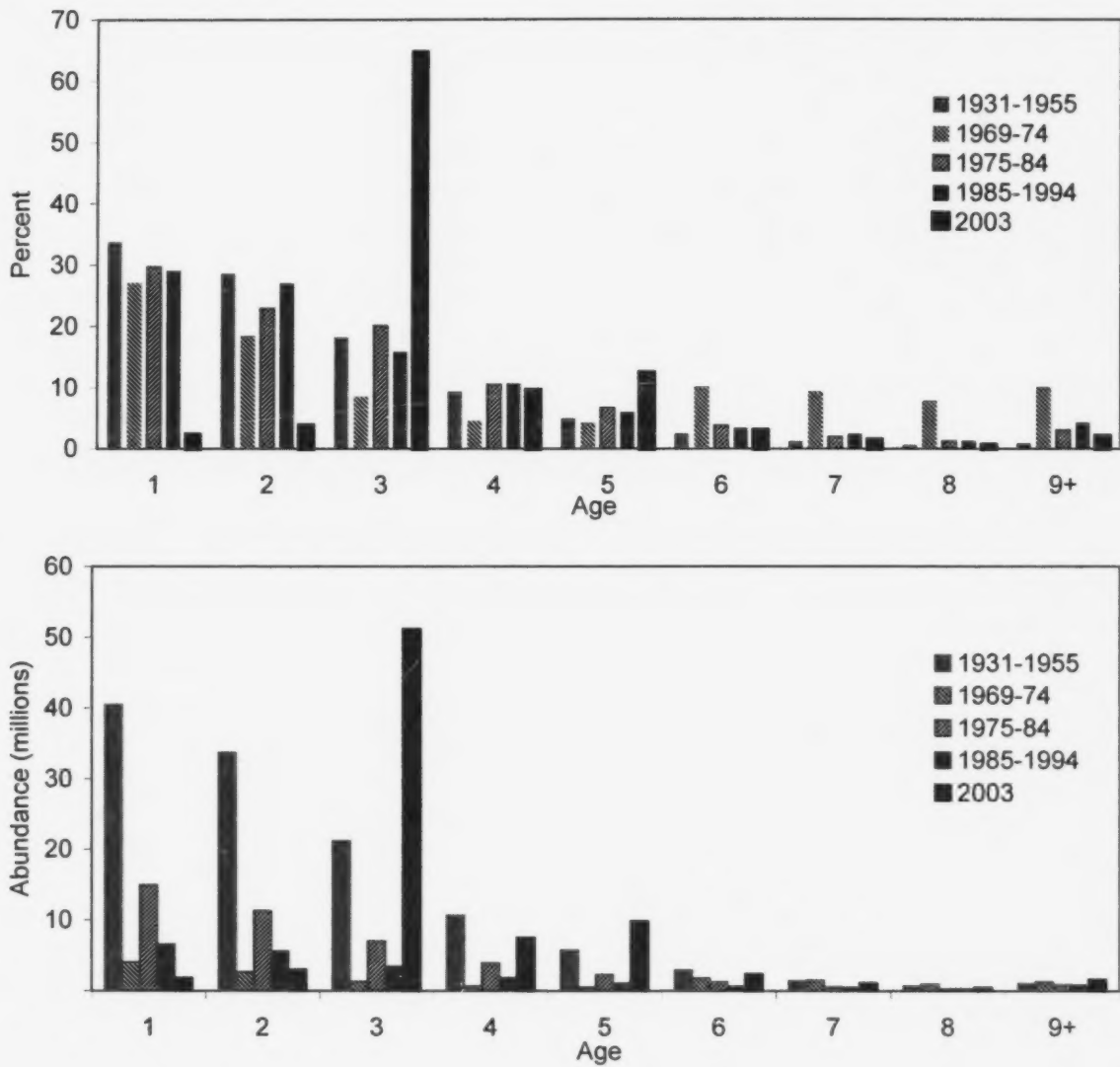


Figure 33. The age composition and absolute abundance at age of the 5Zjm haddock population in 2003 compared to earlier periods.

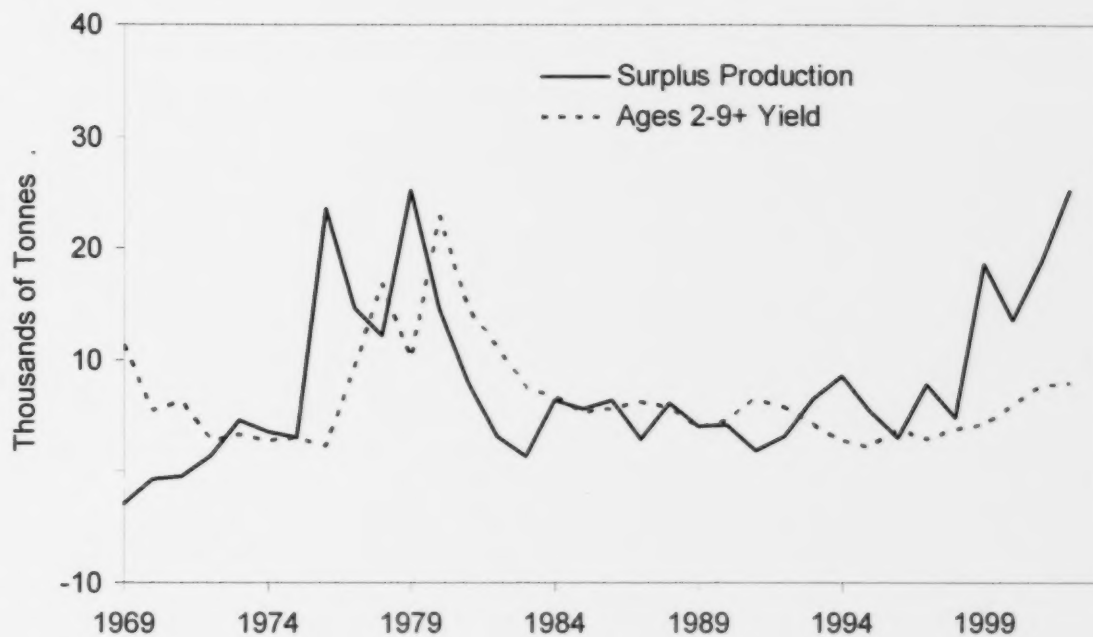


Figure 34. Surplus production of 5Zjm haddock available to the commercial fishery compared to the harvested yield.

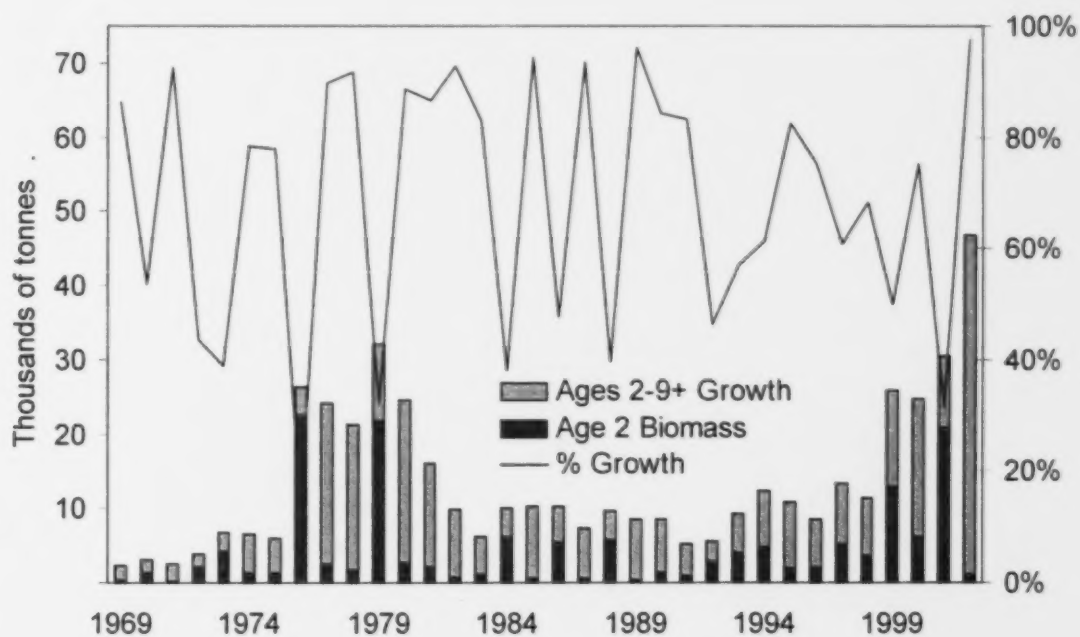


Figure 35. Amount of productivity attributable to growth (ages 2 to 9+) of 5Zjm haddock and the amount contributed by recruitment (age 2).

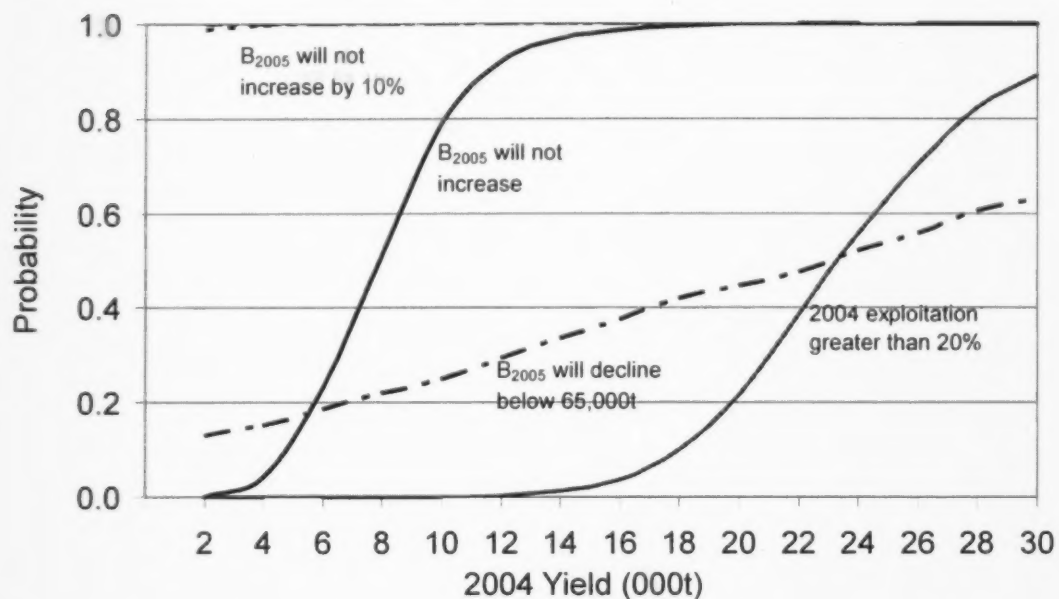


Figure 36. Probability of 2004 exploitation rate exceeding 20%, the $F_{0.1}$ reference level, and of the 2005 ages 3+ biomass being less than the 2004 biomass by 0%, 10% and 20% for 5Zjm haddock at various quotas.

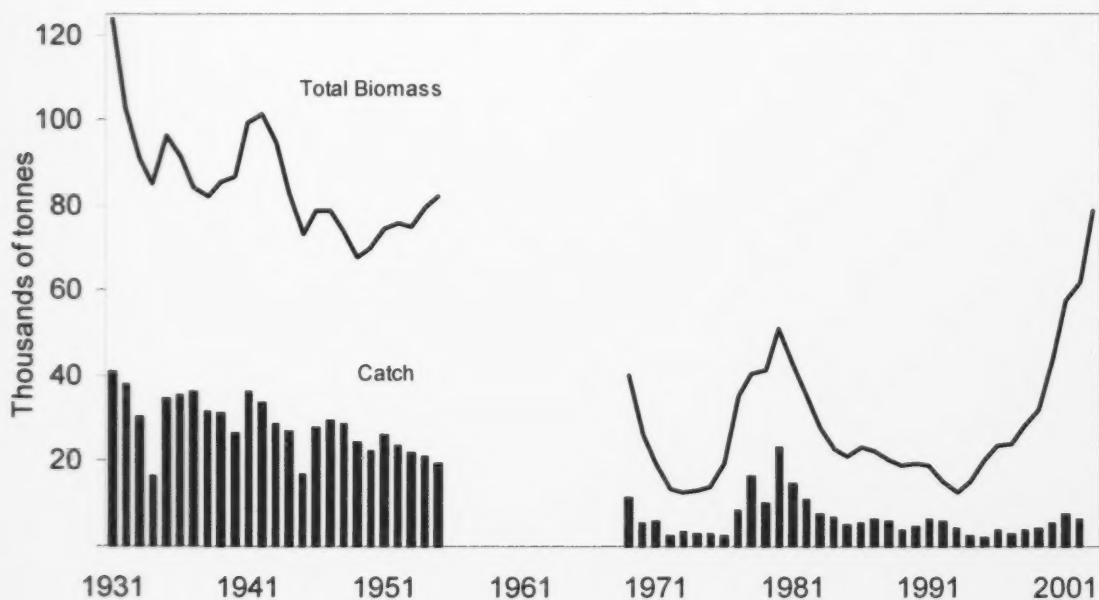


Figure 37. Historical catch and total biomass of haddock in 5Zjm compared to recent catches and biomass.

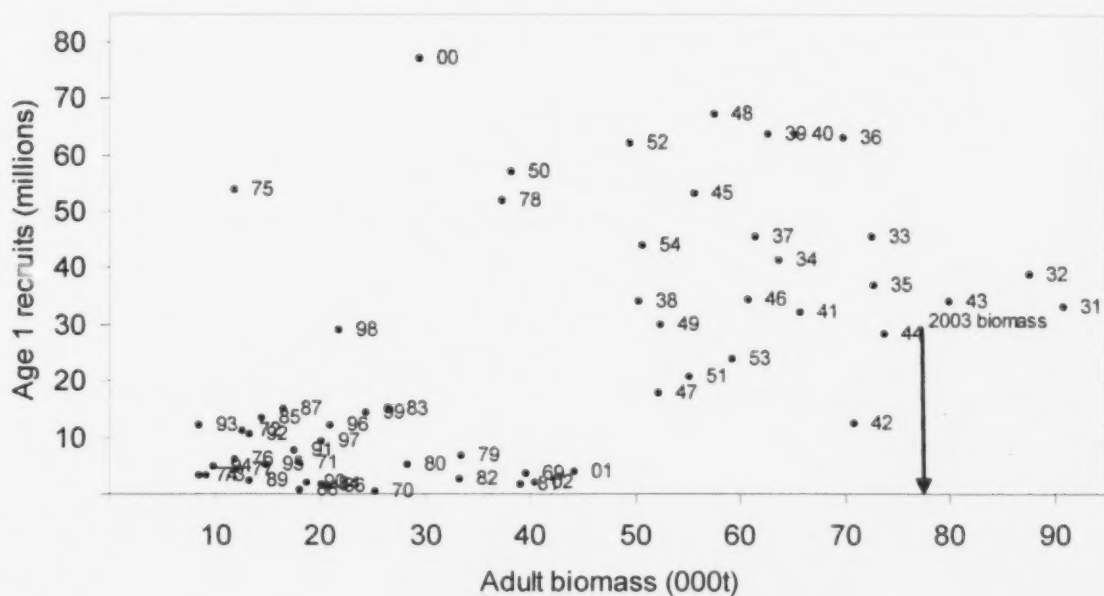


Figure 38. Relationship between adult (ages 3+) 5Zjm haddock biomass and recruits at age 1 from 1931 to 1955 and 1969 to 2001.

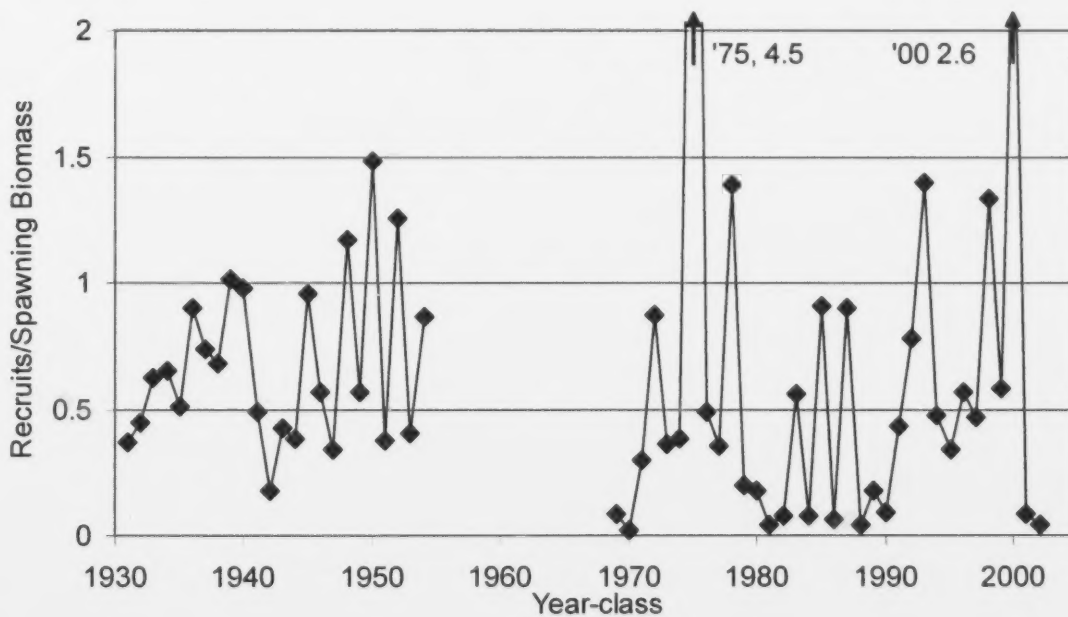


Figure 39. Ratio of recruits (numbers at age 1) to spawning biomass (kg) for 5Zjm haddock suggests that, except for 2001, present survivorship appears comparable to that of the 1930s to 1950s.

Appendix A

Table A1. Intra-reader ageing agreement matrices for the DFO haddock ager, L. Van Eeckhaute (LVE), using haddock ageing material from the 2002 DFO spring survey and the 2000 Canadian fishery in 5Zjm.

DFO 2002 Georges Bank Spring Survey (NED2002002)												Agreement = 96%	
Test Age (LVE)	Production Age (LVE)												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
1	15												15
2		20	1										21
3			9										9
4				15									15
5					5								5
6						9							9
7							2						2
8								5					5
9									5				5
10									2	5			7
11											5		5
12												1	2
Total	15	20	10	15	5	9	2	5	7	5	6	1	100

2000 Commercial Samples													Agreement = 89%	
Test Age (LVE)	Production Age (LVE)													Total
	1	2	3	4	5	6	7	8	9	10	11	13		
1	1	1											2	
2		21	2										23	
3			4										4	
4				21	1								22	
5					6		1						7	
6						6							6	
7							7						7	
8							1	7					8	
9								3	5	1			9	
10								1		4			5	
11											1		1	
13												5	5	
Omitted								1					1	
Total	1	22	6	21	7	6	9	12	5	5	1	5	100	

Table A2. Inter-reader ageing agreement matrix for the DFO haddock ager, L. Van Eeckhaute (LVE), and the NMFS haddock ager, N. Munroe (NM), using haddock ageing material from the 2001 NMFS Georges Bank spring survey.

NMFS 2001 Spring Survey											Agreement = 68%		
DFO Reader (LVE)	NMFS Reader (NM)										Missin g	Omitted	Total
	1	2	3	4	5	6	7	8	9				
1	9	1											10
2	1	16	16										33
3			11	1									12
4			1	15	2						1		19
5				2	7	1							10
6						4	2	1					7
7						1	3	1					5
8								1	1				2
9									1				1
Omitted			1	1	1								3
Total	10	17	29	19	10	6	5	3	2	1			102

